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CONTENTS

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SOME APPLICATIONS OF PHYSICAL CHEMISTRY TO MEDICINE[1]

The growth of knowledge, like most processes of growth, is autocatalytic. It is self stimulating. The discovery of fact, principle or idea speeds the discovery of new facts, principles and ideas. Progress is thereby self accelerating, although the acceleration is not constant, but increases for a time after each discovery only to slow up or to come to a constant velocity until some new catalyst is discovered. A remarkable feature of this growth of science, a feature which shows that knowledge is indeed an organic whole, is that an idea or fact discovered in one branch of science often serves as a catalyst to a very remote and apparently unrelated branch.

Nowhere is this illustrated better than in the repercussions between physics, chemistry, biology and medicine. The study of what is going on in an evacuated glass tube provided with electrodes, when there is a strong difference of potential between those electrodes, results in the discovery by a physicist, Crooks, of the so-called "cathode ray"; study of this ray by another physicist, Röntgen, leads to the discovery of the X-rays set up when the cathode rays impinge on glass, metal or other solid surface, and as a result the physician is provided with a means of seeing the bones, the stomach, intestines, heart, ureters, and gall-bladder of a living man; of learning whether these are normal or not; and he is in addition provided with a means of treating successfully many hitherto hopeless conditions.

But the effects of this discovery do not stop here; even more important to physiology and medicine is the resulting study of the mechanism by which the X-rays act upon the body. For it is clear that if substances are opaque to X-rays, they must absorb such rays. And when they absorb such rays the energy in the ray is passed to some substances in the tissues, or to substances which have been introduced into the cavities of the body to make their outlines visible. Now molecules of substances which have absorbed energy are in a quite different condition from molecules of the same substance which have not. Energy is that which gives the power of acting. So substances which have absorbed energy are thereby rendered far more reactive than they were before.

[1] Lecture given at the University of Buffalo, April 12, 1927, on the Harrington Foundation.

Being thus reactive they become more toxic, or more curative. Or they may be destroyed.

Hence the study of the luminosity of gases in partially evacuated electrode tubes, besides causing a revolution in physical theory, ultimately resulted in providing a method for introducing energy into the interior of the tissues of the body, which energy is useful in destroying tissues which are overgrowing, such as cancers, or various glands, or in destroying parasites.

A tremendous and rapid development of diagnosis and therapeutics, a development still in progress, has thus resulted in medicine from a discovery made in a totally different field of science. It is indeed as if in the body of knowledge an organ called physics secreted a hormone, which led to the intense development of another remote organ, called medicine. And it is almost certain that medicine or biology thus stimulated will ultimately react on physics to produce in its repercussion as great an effect on it. When this repercussion comes it will probably revolutionize the physicist's conception of matter.

It is indeed true that all of the organs of the body of knowledge are thus metabolically and nervously coordinated and they act and react on each other leading either to an acceleration of development of old organs, or to their atrophy, just as in the body of a tadpole, the thyroid hormone enormously stimulates the development of the limb buds, while it produces atrophy of the tail and the gills, organs no longer useful in the changed conditions of the life of the progressive organism.

Nowhere is this interdependence of the sciences better illustrated than in the interrelation of medicine and physical chemistry; and no better example can be found than here of the saying that a scientific man never knows what he is doing. For he, no more than others, can look into the future to see what the consequences of his work will be. The results are always concealed from him. All that he can see is the effect of ideas after they are past. He is blind; for no one can see even sixty seconds into the future. The past is illuminated by the light of memory; the future is wrapped in the impenetrable darkness of fate, or lighted only by the deceptive and ghost-like glimmer of the law of probability.

Physical chemistry itself was in a large measure a result of a discovery by botanists. Plants, as you know, are among the most interesting of animals. They differ from other animals in that they are sessile —they do not move from place to place; and they possess chlorophyll, a wonderful apparatus for catching and utilizing the ethereal vibrations of light. From this captured light they derive their own vitality; and they imprison part of it, which they do not need themselves, in oxygen which turned loose in the air constitutes a great reservoir of vitality from which we and all animals get our life. Now plants have a circulation not so unlike the circulation of the blood of animals. It is a circulation of sap; a sap containing food—mineral and organic—which streams up to the leaves and buds and growing parts and nourishes them. The pressure of this sap was first measured by Stephen Hales, who also measured the pressure of blood, two centuries ago.

It has always been a puzzle to botanists how the movement of this sap is produced, and many of the great botanists have worked upon this problem. Among them were Dutrochet in France, and many years later De Vries in Holland and Pfeffer in Germany. These earlier workers had the idea that the rise of the sap might be due to a process which was similar to that which occurred when a pig's bladder full of sugar solution was placed in water. Water then entered the bladder and a very high pressure was thus generated leading to the distention of the bladder. This process was called osmosis. The passage in of the water was called endosmosis; that of the sugar out, exosmosis. It might be that in the roots, water was thus imbibed and the sap expanded in volume was forced upward and into all the twigs of the plant. Modern work makes it doubtful whether this is the mechanism, but one begins with a simple theory. To make this a scientific theory it was necessary to measure the pressure of sap on the one hand and the pressure which solutions of substances in water were capable of exerting when they expanded, on the other. It was necessary to see whether such an osmotic pressure could account for the rise of the sap.

The botanists De Vries and Pfeffer measured the osmotic pressures of salt and sugar solutions, and largely because of these measurements a new science was born, the science of physical chemistry. The botanists did not know they were creating this new science. They themselves did not solve the problem of the movement of sap. That is a vital problem and according to Professor Bose's recent work, involves the vital pumping activity of certain cells of the plant, analogous in their rhythmicity to the beating of an animal's heart. But while De Vries and Pfeffer did not solve their problem, out of their work two fundamental concepts came; the first was contributed by the great Dutch chemist, van't Hoff. From the observations of Pfeffer he showed that the osmotic pressure measured by the botanist was exactly that pressure which a number of molecules of hydrogen gas equal to the number of sugar molecules in the sugar solution would exert if the molecules of gas were confined in a volume as large as that of the

solution; and furthermore the variation of the osmotic pressure with temperature was the same as that of hydrogen gas with temperature.

This idea of van't Hoff when united with the facts of Pfeffer made a catalyst which stimulated a great volume of work throwing light on the nature of solutions; and it caused that development of physical chemistry, of the application of the methods of physics to the study of chemistry, which resulted in the splendid growth of knowledge in this branch of science which occurred from 1880–1920.

The other great contribution, developing from the facts discovered by these botanists, was that made by Arrhenius. De Vries found that most salt solutions had a higher osmotic pressure than van't Hoff's law of correspondence between osmotic and gas pressure indicated. The Swedish physical chemist, Arrhenius, pointed out that this was probably due to the dissociation of molecules of salt into two or more fragments, a dissociation analogous to that which occurred in some gases, such as nitrogen pentoxide, and that the extra pressure observed was due to these dissociated parts of molecules. Furthermore, he identified the dissociated parts with the ions described by Faraday and Clausius. These ions were electrically charged bodies which carried the current resulting when electrodes were put into a salt solution. This fruitful idea was established as a fact by experiment.

Thus was founded the theory of ionic dissociation which revolutionized chemistry, and of which the application to medicine have been extremely important.

Something further was required, however, to make these two simple and illuminative conceptions of value to medicine. This something was the discovery that such colloids as existed in living matter were electrically charged. This discovery was made by Sir William Hardy in Cambridge, England, about 1898. He found that the protein particles in solution when subjected to the action of electrodes—that is of the electric field—often migrated in the field, sometimes going in the direction of the current to one electrode, sometimes to the other, and sometimes not moving. Since all particles which migrate in an electric field must be electrically charged, this proves that protein colloidal particles were often electrically charged.

This discovery completed the fundamental work on the electrical state of the protoplasmic constituents. Protoplasm was seen to consist of colloids which often at least were electrically charged; and the salts present were also in the form of electrically charged particles.

It is impossible to give those who were not at the time engaged in studying these problems a conception of the wonderfully clarifying effect on biology and medicine of these few simple facts and theories. But a basis was at once given for the explanation of many until then wholly obscure things. The speaker was so fortunate as to have a part in this great clarification. It provided a scientific basis for the many important contributions of electro therapeutics, including the recent development of diathermy; it gave an explanation, incomplete to be sure, of the electrical phenomena of living things and of electrical stimulation and depression. The reason why the acidity or alkalinity of the tissues was so important for their normal function was seen to be a natural result of this dissociation, since any change in hydroxyl or hydrogen ion concentration at once changes the state of aggregation and the physiological activity of these proteins. The discovery of the importance of hydrogen and hydroxyl ions led to the recognition of the diseased state of acidosis; of the importance of the maintenance of the neutrality of the tissues and organs. And recently it has led also to the recognition of the evil results of deviation in the other direction toward alkalosis. The pathological states of acidosis and alkalosis appeared from this discovery first as a probability, and then by experimentation as established facts. And the results of upsetting the acid-base equilibrium, or the balance of the salt solution, in the blood and tissues, could be forecast in theory and were established in practice.

For the first time, also, we had an explanation of why mercury, silver, gold and copper salts should be so vastly more toxic than salts of sodium, potassium, magnesium, calcium and iron. This followed from the discovery that the amount of energy liberated when the ions lost their charges was a measure of their toxicity. Sodium, in the metallic form, was so extremely toxic and caustic because it contained a vast store of energy which it liberated when it changed to the ionic form; and mercury and silver in the ionic or salt form were so toxic and caustic because they contained a large amount of energy which is liberated in changing toward the state of metallic mercury or silver or when united with any substance.

There was still another of its concepts which was destined to throw great light on physiological and pathological processes. This was the concept of oxidation developed by physical chemistry. It may be called, indeed, the electric theory of oxidation. It was the next step necessary to take if we were to be able to give an electrical description of life; for oxidation—that is respiration—is the means by which all living things get their energy.

Before the era of physical chemistry there was no good conception of oxidation other than the ordinary one of union with oxygen. This is of course the

original meaning of the word oxidation, which signifies literally *a souring,* for the reason that acids are produced when oxidation occurs of most although not of all materials. The word oxygen itself means literally the "maker of acids." But there was no general explanation of the nature of all oxidations such as that of metals by acid, of the iodine in iodides by ferric salts and so on, where oxygen was not involved. The physical chemist discovered what was really at the bottom of all oxidation whether they were due to oxygen or not. In all cases of oxidation he found that there is an increase in the number of positive valences in the substance oxidized, or, what is equivalent to this, a decrease in the negative valences. And, finally, when the electrical and electronic nature of valence was finally understood a few years ago, it was seen that in every case of oxidation, the oxidized substance lost a negative electron, and thus gained a positive charge. In other words, in every oxidation there is always a flow of electricity—of positive electricity—since the current is always supposed to be in the direction of movement of the positive, from the oxidizing to the oxidized body. Oxidation, then, was seen to be in reality also an electrical affair; and every electrical current to be endowed with the potentialities of oxidizing. The great value of this conception of physical chemistry to medicine consisted in that it gave for the first time a rational explanation of the electrical currents which are found everywhere in the body. As every physician knows, whenever the heart beats there is an electrical disturbance which is propagated from the heart throughout the body. By leading off from the hands or from one of them and the feet, or from tongue to foot, or in other ways, these currents may be made to traverse circuits outside the body, and are then readily perceived and registered by a galvanometer. These extra corporeal currents have now become a valuable means of investigating the physiology of the heart beat and of aid in diagnosis of heart disease of various kinds. The exact way in which these currents are generated in the heart is still not certainly known, but enough is known to permit the statement that they are correlated with the process of oxidation which occurs in the heart muscle and which supplies the energy for its muscular contraction.

Moreover, it is now becoming clear that these currents, thus traversing the body, are in some cases at least of very great importance to it. Many years ago the speaker discovered that the well-known polarity which all organisms show, both plant and animal, was at least in some instances accompanied by, if it was not the expression of, an electrical polarity. By organic polarity I mean the difference between the root and the apical end of willow and other stems; the tendency of the apical bud to hold back the development of buds below it; the tendency of the piece of a hydroid, a sessile animal, to form a polyp at one end and stolons or roots at the other. I found that that part of the animal which would most rapidly regenerate a part cut off was always electrically negative (to the current outside the body) to the part which regenerated more slowly, and I suggested that these differences of electrical potential between different parts of an organism, small though they were, might be of very great value particularly in the differentiation of organs and tissues in the course of embryonic development.

This suggestion has now been put on a very much firmer basis by the discovery by Child that there is a gradient of metabolism, which is accompanied by a gradient of an electrical kind, in all developing organisms; the nervous system, or its fundament, is the point of maximum growth and chemical change, and this point is electro-negative to the rest of the body; and that this gradient in some way or other controls development along the axis. It is an important factor in inheritance and in the attainment of the form of any animal. Furthermore, Lund has succeeded in showing that by altering the electrical polarity it is possible by minute currents to alter the character of the development; thus showing that my guess as to the importance of these currents in embryology was correct.

The physical chemical conception of the electrical nature of oxidation has, therefore, been of importance in interpreting the cause of the electrical phenomena of living things and has helped in the unraveling of the complicated mechanism of inheritance. It explains at once the dependence of these electrical currents upon respiration and vitality, and accounts for their origin.

In another way too this electrical theory of oxidation is of value although not many applications of the facts to medicine have yet been made. It furnishes a basis for understanding why some things can be oxidized and others can not be. Clark, in Washington, has particularly shown the relation between the ease of oxidation of any substance and what is known as the potential of an oxidizing electrode immersed in a solution in which the substance is undergoing oxidation. Among the results obtained by the use of this method has been the proof that when methemoglobin is formed in the blood there has been an oxidation of the iron in the hemoglobin molecule so that it has become ferric iron; whereas in the ordinary oxyhemoglobin the iron is not oxidized but is in the ferrous state. This discovery will probably eventually throw light on the mechanism of hemoglobin respiration and will perhaps enable us to

understand the nature of the union between oxygen and hemoglobin.

These are simply a few of the applications in medicine and cognate sciences of the fundamental conception of physical chemistry that all oxidation is a process of an electrical nature.

But there is a more important aspect even of this work than those presented. The great problem of biology is the source and nature of our vitality. It is known that as long as we live we continue to breathe and that variations in our vitality are accompanied by variations in tissue respiration and by electrical phenomena of the highest interest. I will mention only one of these curious phenomena which has to do with the alteration of the electrical resistance of the body under stress of the emotions. This phase of animal electricity was being particularly studied five or six years ago by Professor A. D. Waller, the able English physiologist, just before his death. The effect of emotion was demonstrated to me by his son, Mr. J. C. Waller. An electrode moistened with salt water was put on the palm and another on the middle of the back of my hand and these electrodes were connected with a galvanometer. It was then found that there was a current running through the tissues of my hand, from back to front or *vice versa.* I do not for the moment recall which way it went, but that is of no consequence for our purpose. When this current was balanced through the galvanometer by another current just equal to it and running in the opposite direction, the galvanometer mirror came to rest and the spot of light reflected from this mirror remained steady. A horn of a motor was then suddenly sounded behind me. The instant this noise was made the galvanometer mirror was deflected. There was an instantaneous increase in the current through the palm of my hand, due either to an increased electromotive force or decreased resistance of some or all of the tissues of the hand under the influence of the emotion caused by the noise. The current through the galvanometer was thus increased and the spot of light swung off the scale of the galvanometer. After it returned to normal the following experiment was tried. Mr. Waller picked up a pin where I could see him and started toward me saying: "I am going to prick you with this pin." The instant he said this and approached me, the current of my hand changed again and just in the same direction as before and the spot of light swung off the scale, so violent was the electrical disturbance set up by this remark and action.

Whatever explanation may be given of this curious alteration in the electrical resistance or e.m.f. of the body under the influence of emotion, in both these cases probably the emotion of fear, they are certainly sufficiently remarkable. They merit a careful study and, as you all know, Dr. Crile, with his great genius for seeing far into things, has at once attacked this very problem and brought it into relation with many diseased states. According to his view there is some kind of a reciprocal variation in resistance between the liver and brain.

No one can predict the future, but I have a feeling that the investigation and elucidation of these curious electrical disturbances, which are usually correlated with oxidative changes and with the emotions, will ultimately throw great light on the nature of vitality, and also perhaps on the causes of disturbed personality, states of mind, which have at present no tangible clue as to their origin.

Among the most important developments in physical chemistry of recent days has been the development of photochemistry. This seems to be the great field of the immediate future. Here there have been two very fruitful ideas or conceptions introduced which are playing havoc with old theories of chemistry and letting in a flood of light upon regions which have been obscure. These two fundamental conceptions are (1), the idea that molecules and atoms may exist in several different forms, these forms differing in the amount of energy they contain; and (2), what is known as the quantum theory. The quantum theory is the theory that energy is radiated through space in definite units which are called quanta. A quantum of energy is numerically equal to the product of a constant, the quantum constant, of which the value is 6.547×10^{-27} ergs seconds, multiplied by the frequency of the vibration of the energy radiated.

The first of these conceptions, that atoms and molecules which are alike in other respects may differ in the amount of energy they contain and so behave differently, is due in large measure, in its later development at least, to the work of Baly, of Liverpool, but is an essential part of the conception of the atom developed by Niels Bohr. Bohr showed that the atom of hydrogen might exist in several different forms, the single electron which it contains revolving about the positive center in several different possible orbits. When the electron was farthest out the electron orbit had the largest amount of potential energy in it; and as it was easily displaced from this position to one of the orbits nearer the nucleus, it radiated the difference of energy of the two orbits when it was displaced. This conception is of very great importance to physiology and medicine. It means that a substance which is in its stable and energy poor form, where it is very unreactive, may be raised by the absorption of energy to another form in which it is very reactive and unstable. Thus chlorophyll when

it absorbs energy from the sunlight passes the energy thus absorbed, or a part of it, into the oxygen of carbonic dioxide. The oxygen thus enriched with energy dissociates from the carbon atom, leaving the latter to unite with water to make the carbohydrates. The oxygen contains more energy and is larger than it was when in the form of carbon dioxide as some of the electrons are out in larger orbits. When this oxygen is drawn into our lungs and sent by the blood to the tissues it unites with the cells of the body and passes this imprisoned sunlight over to them; and it is in this way that we get energy. The oxygen atom when it has lost its energy returns again to the form of the oxygen in carbon dioxide. If there is mentality, as well as energy, in sunlight, it is quite possible that we secure our mentality also from oxygen; and that in this way our vitality is derived from the sun. The energy passed to the living matter by the oxygen is in turn passed by it to the foodstuffs, which as they come into the body are in their most stable and unreactive form. The carbohydrates, fats and proteins, thus enriched by this energy which came from the oxygen, are rendered highly reactive and are enabled thus to change into the myriad of things they change into in the course of metabolism. Thus this conception of atoms having available energy in them and existing in different states, of which the most reactive may be called the living state, enables us to form a pretty clear idea of the fundamental metabolism of the body. Above all, it makes clear for the first time why oxygen is necessary for the metabolism of the body, and why growth stops as soon as anesthesia is produced and respiration stops.

Probably the most remarkable work along these lines of photochemistry is at present being done by Professor Baly, of the University of Liverpool, in England. He has succeeded in making several typical vital syntheses by means of ultra-violet light. He has thus made possible a concrete theory of the origin of living matter on the earth's surface by the action of light.

This same conception makes clear also why light is necessary for the proper development of the bones and teeth. Vitamine D, the antirachitic one, is indeed nothing else apparently than ergosterol which has been enriched in energy by the absorption of light. It is either the enriched ergosterol itself, or a derivative of the enriched form.

The second conception, that of the radiation of energy in quanta, is at present upsetting the old idea of light and matter. It is having also an effect in biology. Certain frequencies, or only certain quanta, are absorbed by the blood pigment, hemoglobin. It is a very important and wholly unsolved problem what becomes of this energy which is absorbed. Is it reradiated at a different wave-length or is it passed on to cholesterol or some other constituent of the wall of the red blood cell so as to make the antirachitic vitamine or some other vitamine? Why is the blood red? It must be that the particular light absorbed is of use to the body in some way or other. I leave this problem with you to reflect upon. It may be that the healing power of light on wounds may be an indirect effect of the absorption of light by the blood pigment rather than a direct effect upon the wound tissue itself. Perhaps its action in tuberculosis is also correlated with this red color. What we need is the study of the particular wave-lengths of quanta of energy which are made use of in tuberculosis and in the healing of wounds, in the prevention of rickets and so on. Perhaps each tissue may have a favorable reaction to some specific frequency of the light, absorbing certain quanta but not others.

In the University of Cincinnati some very interesting experiments are being carried out along these lines. It has been found for example that bacteria are not killed by all ultra-violet light rays, but only by certain specific wave-lengths. And the enzymes are killed by other frequencies, so that it has been possible to sterilize various enzymes without in any way injuring them by exposing them to certain specific wave-lengths. This work of Professor Schneider and his associates may have very important results for the sterilization of vaccines, serums and so on. In other words, the lethal effect of light, and particularly of ultra-violet light, does not increase gradually as the wave-lengths of light used are shortened and the frequency and energy is increased, but no effect is produced until a certain frequency, a certain definite amount of energy, is reached when a very fatal action is found to occur. There is no doubt that the application of the newer conceptions of radiant energy will greatly enlarge the usefulness of ultra-violet light, X-rays and ordinary light, in their therapeutic applications. Photochemistry is the newest of the branches of physical chemistry but it promises to be one of the most valuable in its medical applications.

Still another development of physical chemistry and physics of recent years promises to be of great value in biology. I refer to the cathode rays and radio-activity. The effects of negative electrons when shot out of atoms or poured upon living tissue from a cathode ray tube are remarkable. I will first consider the latter way of applying them. The wonderful tube, recently perfected by Dr. Coolidge, of the General Electric Company, enables us to apply electrons to tissues in far greater dose and traveling with far greater speed than has been possible hitherto. What the ultimate effects of this electrical bombard-

ment of tissues are it is too soon to say. Certainly, however, their effects are striking in the extreme. When the cathode particles traveling at high speed strike any object they do several things. They cause many things to fluoresce. They generate also very short X-rays which penetrate the tissues much deeper than the cathode particles themselves can do. Even a second of exposure of the belly of a rat to a sufficient dose will kill the animal not immediately, but after a certain time. The rays are extremely destructive, as the amount of energy thrown upon the spot by these particles moving almost with the speed of light is very great. Whatever the ultimate usefulness in medicine of this tube may prove to be, it has placed in the hands of the investigator a new instrument; and we may look forward with confidence to useful knowledge derived from its employment.

But one of the most interesting of the recent works in this direction is that of the Dutch physiologist, Zwaardemaker. We have atoms within us which are generating these cathode rays. So far as we know at present the element potassium is the only element in the body which is radioactive. It is the only element which generates cathode rays at any other than very rare intervals. The whole of the very weak radioactivity of our tissues is due to the presence of this element. Some atoms of potassium are going to pieces every second in our bodies. When they do so disintegrate they discharge a negative electron which is moving at about two thirds of the velocity of light and the rest of the atom changes into something else. What that something else is, is not known, I believe. A negative electron moving almost with the velocity of light may cause very remarkable things to happen in any molecule it passes through. Potassium is for some reason necessary for all forms of life. Howell found that it was necessary in the heart for the impulse from the vagus nerve to reach and stop the heart. Zwaardemaker has suggested that it is necessary perhaps for the sensitivity of every synapse in the body.

Zwaardemaker has made the following calculations:

There are in the body about 40 grams of potassium. This is an enormous number of atoms. It is approximately 6×10^{23}. The radioactivity of potassium is small when compared with radium. It is only about four one millionths as active as radium. The total number of atoms decomposing per second is not large, but in the body it is 80,000. Eighty thousand atoms of potassium then are decomposed in our tissues every second and discharging this number of electrons at a very high velocity. These electrons have 0.022 ergs of kinetic energy, or they furnish 1,900 ergs per day. This is 45 microgram-calories. The amount of energy thus liberated is hence very small, almost inconceivably small. It is in the ratio of 1: 35.5 billions when compared with the whole basal metabolism. But small though it is it may be of very great importance. Zwaardemaker states that it is possible to replace the potassium in the perfusion fluid of the heart with an equal dose of other radioactive material such as radium emanation or uranium. He computes that in one eighth of a cc. of our bodies there are eight trillion potassium atoms, of which each second one arrives at the end of its life as potassium and changes into something else, at the same time shooting out of its nucleus a single negative electron with one third microerg of energy. Of this energy one half is lost in 1 mm.; and in 2 mm. only one fourth remains. This charge traveling at high speed will effect the molecules it passes through. Every part of the one eighth of a cc. is every second subjected to this influence. In muscle and nerve especially this is happening, as they contain the most potassium; in bone and lungs it is almost absent. Therefore, says Zwaardemaker, every second there is a stimulus of one third microerg applied in every one eighth cc. of the body. "In the presence of the proper receptors noticeable results from a stimulus of this size might be expected." "For example, the minimum energy perceived by the eye is about 0.7×10^{-10} ergs. The energy of a beta particle from potassium is 4,000 times this. A star of the first magnitude twinkles at night with 30 to 40 times less energy than that of a potassium atom when it explodes. The amount of energy necessary for the ear to hear is 0.3×10^{-8} ergs per second on the drum. In 17 thousandths of a second, the minimum time necessary for the perception of sound, this would give 1.1×10^{-10} ergs, which is the one twenty-five hundredth part of that of a potassium atom on exploding. The energy of an ordinary conversational voice at two meters distance is figured to be on the ear drum 1×10^{-9} ergs. The potassium atom has 275 times this amount. Zwaardemaker suggested in this way that the energy thus set free in the proper place and with the proper receptors to catch it may be a very important factor in the automaticity and activity of the nervous and muscular and other systems of the body.

There are still other even more fundamental conceptions than any yet quoted from the field of physical chemistry, which will probably in the course of time be applied to biology and medicine. These are the new conceptions of the nature of time and mass and energy which have already upset all the foundations of mechanics and physics. Their effects on biology are already beginning. No one can say what they will do to and for this science; they seem, however, to have the effect of putting mentality of some kind into the inorganic as well as the organic and thus

to open entirely new vistas in biology. They suggest a method by which matter can be made; and they offer, or seem to offer, an escape from the purely mechanistic theories of conduct and life. It would take much longer, however, to consider these revolutionary conceptions than we have time for to-night; and I will only call your attention to them in passing. Those of us who are alive twenty years from now will probably in that time have passed through a revolution of biological thought as great as any the world has ever seen. And this revolution will unquestionably have important consequences for the physician and his patient.

I have by no means exhausted the applications of physical chemistry to medicine. In fact, I have mentioned only a very few which have particularly interested me. But I shall have compassion on you and stop with these.

I believe and hope that the development in our knowledge of energy and matter and vitality, developments which are impending, will stimulate above all the science of therapeutics, that step-child Cinderella, at present hardly tolerated, and boxed about most unkindly, to our great disgrace, in every American medical school. I believe physical chemistry, or physics with chemistry, is spinning for her a new dress, a dress shining and splendid. Once bedight in it she will dazzle the eye and warm the heart of even the oldest, most experienced and most cynical among us, and be seen for what she is, the fairest daughter among the medical sciences. And I venture to say that in no way can the science of physical chemistry serve medicine better, playing the rôle of Prince Charming, than by leading this Cinderella from her position of drudge to the throne of medicine.

For it is the neglect of therapeutics, which is, I believe, one of the most serious shortcomings of present-day medicine. And it is in this field that physical chemistry can contribute most.

Albert P. Mathews
University of Cincinnati

THE ABUSE OF WATER[1]

It would appear obvious that the fundamental principles of science must not be dependent upon any casual feature, such as environment. Thus the laws of gravitation should be just as rigid on the sun or the moon as on the earth. In a science which is mainly experimental, also, such as chemistry, it would seem to be a simple matter to insure that the results of experiments were not being misinterpreted due to their environment. This might be done either by changing the conditions under which the experiments were being conducted, or by a rigorous study of the existent conditions and of their possible influence. Nevertheless, the history of chemistry affords numerous instances where whole schools of investigators have gone astray through neglect of such precautions.

A noteworthy example is given by the famous phlogiston theory, which predicated that substances which were changed by heat did so through loss of phlogiston. We now know that such substances are actually changed through combination with the oxygen of the air in which they are heated, but this explanation did not secure acceptance until the nature and properties of oxygen had been thoroughly investigated and until the effect of heating substances in the absence of oxygen had been noted. At the present time, we still allow our oxygen environment to influence our definitions to some extent. We call a body "combustible" if it burns in the air, and "non-combustible" if it does not. That such terms have no strict scientific meaning is evident if we imagine ourselves to be translated, for a moment, to a world in which the atmosphere contained hydrogen as an active component instead of oxygen. In such a world fires would be extinguished by sprinkling gasoline on them, and non-inflammable buildings would consist of solid paraffin.

The modern science of physical chemistry has been almost wholly developed through the study of very dilute aqueous solutions, and a scrutiny of this water environment suffices to show us that our present viewpoint is considerably distorted and incomplete in many respects. Water itself is almost as much a mystery to the chemist of to-day as oxygen was to Priestley. We call it H_2O in the text-books, but liquid water certainly does not consist of simple molecules of H_2O. What the actual complexes are, and how they are changed on addition of a solute, are points on which we are entirely ignorant. The theory of dilute solutions founded by van't Hoff avoids the difficulty by assuming that we may regard the solute as existent in the gaseous state, neglecting the water absolutely as so much "dead space." This idea, though still popular in the classroom, has been shown by the more modern theory of ideal solutions to be quite erroneous. There is no direct analogy between solutions and gases; a substance such as sugar, when dissolved in liquid water, is not in the gaseous state but in the liquid. In a liquid solvent, solution and fusion are identical terms; sugar melts in hot tea just as ice melts in iced tea. The two components of a solution, solvent and solute, must be considered as equally important, but at present our procedure is to let familiarity breed contempt and to

[1] Abstract of an address delivered before the Institute of Chemistry of the American Chemical Society, State College, Pa., July 28, 1927.

ignore the water altogether. Consequently the identity of freezing-point depression and solubility laws is seldom made apparent to the student; he is taught the same fact twice under two different names.

When hydrogen chloride HCl is dissolved in water H_2O, two substances which do not conduct the electric current separately give a solution which is an excellent conductor. We "explain" this by assuming that the hydrogen chloride HCl is split up, or ionized, into positively charged H^+ and negatively charged Cl^-, and that the migration of those ions towards the electrodes accounts for the conductance. Why, in a mixture of HCl and HOH, two substances with perfectly similar characteristics, should one be active and the other quite inert? Simply because we are so familiar with water (or think we are) that we do not trouble to take it into consideration. Suppose we lived in a world in which another liquid, say sulphuric acid, was the familiar reference liquid, and suppose that in this world an ingenious chemist discovered a hitherto unknown substance, water. He would put a little of it into the practically non-conducting solvent, 100 per cent. H_2SO_4, and would decide that the solution was an excellent conductor. This would apparently justify the announcement in the scientific press that the new compound HOH was highly ionized in a solution—a typical strong electrolyte—a very polar substance—almost completely broken up into H^+ and OH^-. Yet the chemists of another world, in which acetic acid was the reference liquid, would agree that water was a weak electrolyte, and those of a third world, in which ethyl alcohol was supreme, would call it a non-electrolyte.

Evidently, to develop a consistent theory of conducting solutions, we have again to insist on the equality of solvent and solute. We can not obtain a true conception of ionization, either by the classical theory of Arrhenius or by the more recent theory of Debye, unless we consider the two components of a conducting solution impartially. A theory of ionization has been presented by Werner, indeed, which goes to the opposite extreme, regarding water as the *only* substance which ionizes directly in aqueous solution. This theory is just as good as the currently accepted view, and leads to the same mathematical conclusions.

That the study of systems in a non-aqueous environment will certainly develop results of great significance in chemistry has been shown by the excellent work of Franklin and his coworkers on reactions in liquid ammonia. That the closer study of water itself will open up new avenues of advance has been clearly indicated by the remarkable work of Baker on systems from which the last minute traces of water have been removed. Instead of being a substance which can be neglected, water is perhaps the most reactive of all substances. When we cease to abuse it and recognize its proper importance, a new and more general chemistry of solutions will be born.

JAMES KENDALL

NEW YORK UNIVERSITY

FRANK W. VERY

WITH the death of Frank Washington Very on November 23, 1927, there ended the earthly career of an active investigator in the fields of astrophysics, meteorology and aerodynamics. Born in Salem, Mass., in 1852, the son of Washington and Martha (Leach) Very, he specialized in chemistry at the Massachusetts Institute of Technology and received his degree of bachelor of science there in 1873. He entered the field of astronomy and became first assistant at the Allegheny Observatory, 1878–1895, under the direction of Dr. S. P. Langley; was professor of astronomy at Western University, Pennsylvania, 1890–1895, and director of Ladd Observatory of Brown University, 1896–1897. Afterward he was engaged in researches on astrophysics and other allied sciences at Westwood, Mass. In 1893 he married Portia Mary Vickers, of Glenshaw, Pa., and there survive five children, Arthur, Ronald, Mrs. E. R. Brown, Mrs. A. C. Bartlett and Miss Marjorie Very. Very was a pioneer in several fields of science and loved the work of the pioneer.

He was a man of great originality and had an intense enthusiasm in the pursuit of knowledge. His activities in science covered a wide range of subjects. He assisted Langley for ten years in his epoch-making work in astronomy and in the aerodynamic studies on which Langley based his model flying machine weighing 25 pounds which successfully flew over the waters of the Potomac. He assisted Frank W. Bigelow in the preparation of his books on the thermodynamics of the atmosphere and cooperated with Percival Lowell in his studies of the atmospheres of the planets. In 1900 he was at work with radio experts in devising a system of signals for our weather bureau by means of which information from vessels at sea might be received by radio then in its early stages. He also assisted Dr. Williams in the study of the application of X-rays to medical practice. At the same time he was carrying on a large amount of original work on his own account. Probably his greatest contributions to science were his studies of the moon's surface temperature and his studies of the absorption of heat by our atmosphere, each of which filled a large volume when published. The last was published as "Bulletin G" by the United States Weather Bureau in 1900. By ingenious methods he

applied the bolometer, invented by Langley, to the problem of lunar temperatures and showed that at lunar midday the moon's surface, unprotected by an atmosphere, rose to a temperature exceeding that of boiling water, while at night the temperature fell far below the freezing point.

This was the pioneer effort in the measurement of the surface temperatures of the moon and planets which have since been carried on so successfully by Slipher, Coblentz and others. Our knowledge of the absorption of solar heat by our atmosphere, in spite of the large amount of work on its investigation, is still largely undeveloped, so that Very's work stands to point the way to others.

Very was of a philosophical temperament and he was never so happy as when speculating on the great problems of the universe. His conclusions were frequently out of the ordinary beat and there were sometimes developed sharp differences with his fellow investigators, but he amiably took these differences as part of what was to be expected in life and went on uninterruptedly with his tasks.

He was profoundly impressed by the contributions of Swedenborg to philosophy, science and religion and during the last years of his life was engaged in explaining these contributions in the language of modern science.

His task in life was to enlarge the boundaries of human knowledge and to show that there was no conflict between science and religion. He worked with these ideals ever in view.

H. H. Clayton

Canton, Mass.

SCIENTIFIC EVENTS

BUILDING PROGRAM OF THE U. S. DEPARTMENT OF AGRICULTURE

The plans for the building program for the U. S. Department of Agriculture in Washington were announced by the Treasury Department on November 16, according to a statement in the *Official Record* of the department. They indicate that when the whole program is completed the Department of Agriculture will be housed in one of the largest office structures in the world. Bids were opened on December 8 for the excavation work for the building, which will connect the present east and west wings. This unit will be the first to be built under the plans. The Department of Justice is arranging for condemnation proceedings for the acquisition by the government of the first of three squares of private property which eventually will be occupied by the structure. These three squares are those between B and C Streets and between Fourteenth and Twelfth Streets, S. W.

The plans call for an extensible building, one that may be added to indefinitely according to requirements for space in the future. The unit that is to be built first, the one filling in between the present east and west wings, will complete the façade on the Mall. B Street will not be closed. On the south side of B Street, immediately and symmetrically behind the marble structure in the Mall, will be a five-story unit more than 1,000 feet long over all from east to west. Behind this unit other units will be built as time goes on as the need for more space requires. The extensible building will follow a gridiron scheme with an axis perpendicular to the center of the administration unit in the Mall.

The extensible building will run from Fourteenth Street to Twelfth Street. Eventually Linworth Place and Thirteenth Street between B and C Streets will be closed and the space occupied by the buildings and its courts.

Although the extensible building will be less monumental in nature than the administration building in the Mall, it will have a north façade along B Street of impressive dignity.

The new central unit connecting the present wings is to cost not more than $2,000,000, and the congress has appropriated $400,000 toward this particular part of the program. For the total cost of site and construction of the extensible building south of B Street congress has authorized a total expenditure of $5,750,000 and has already appropriated $1,200,000 of this amount.

The new unit which is to join the wings is to be about 176 by 170 feet on the ground and that unit of the extensible building which will be built first will be 241 feet by 483 feet on the ground.

GUIDE-LECTURE TOURS AT THE FIELD MUSEUM

Beginning on December 1 a new system of guide-lecture tours was instituted at the Field Museum of Natural History, according to an announcement by D. C. Davies, director of the museum.

These tours, a service for which no charge is made, are designed to aid visitors with a limited amount of time at their disposal to find easily and enjoy the best exhibits among the institution's large collections from all ages and all parts of the world, and to assist persons interested in particular subjects to get the most out of the exhibits illustrating those special subjects.

Under the new plan there will be every Thursday, starting at 11 a. m. and 3 p. m., two general tours touching the important exhibits of all four departments of museum exhibits—anthropology, botany,

geology and zoology. These will provide a quick, convenient survey of the most striking features for the visitor who has but little time to spare. The guide lecturers conducting the parties will give informative talks before each of the exhibits.

On the other days when guide-lectures are to be given—Mondays, Tuesdays, Wednesdays and Fridays—individual sections of the museum will be studied, each subject being treated in more detail. Each month a schedule will be drawn up and announced, so that the person with specialized interests may come when his subject is to be taken up. Eventually, under this plan, all sections of the museum will receive this specialized study treatment. Persons with a variety of interests may profitably attend a large part or all of the lectures. Students of high schools, colleges and universities are expected to find the guide-lecture courses particularly valuable as a supplement to their regular studies.

Following is the schedule of guide-lecture tours for December, in addition to the Thursday general tours:

Dec. 2—11:00 A. M., Eskimos.
3:00 P. M., Systematic mammals.
Dec. 5—11:00 A. M., Northwest coast Indians.
3:00 P. M., Precious and base metals; building stones.
Dec. 6—11:00 A. M., Woodland Indians.
3:00 P. M., Plant life.
Dec. 7—11:00 A. M., Great plains Indians.
3:00 P. M., North American and African game animals.
Dec. 9—11:00 A. M., California Indians; nomadic tribes of southwest.
3:00 P. M., Petroleum, coal, clays, sands.
Dec. 12—11:00 A. M., Sedentary tribes of southwest.
3:00 P. M., Skeletons.
Dec. 13—11:00 A. M., Archeology of Mexico.
3:00 P. M., Economic botany.
Dec. 14—11:00 A. M., South American Indians.
3:00 P. M., Systematic minerals and meteorites.
Dec. 15—11:00 A. M., Melanesia.
3:00 P. M., Fish and reptiles.
Dec. 19—11:00 A. M., Italian archeology.
3:00 P. M., Physical geology.
Dec. 20—11:00 A. M., China.
3:00 P. M., Gems.
Dec. 21—11:00 A. M., Tibet.
3:00 P. M., Marine invertebrates.
Dec. 23—11:00 A. M., Children's toys of the world.
3:00 P. M., North American trees.
Dec. 27—11:00 A. M., Reindeer and relatives.
3:00 P. M., Life of birds.
Dec. 28—11:00 A. M., Historical geology.
3:00 P. M., Textiles.
Dec. 30—11:00 A. M., Pewter and glass.
3:00 P. M., Systematic birds.

THE CLEVELAND MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA

The official program of the mid-winter meeting of the Geological Society of America, to be held in Cleveland, December 29, 30 and 31, has been issued. Three affiliated and closely associated societies, the Paleontological Society, the Mineralogical Society of America and the Society of Economic Geologists, will hold meetings at the same time and place. Section E of the American Association for the Advancement of Science, which will meet at Nashville, announces its program also with this geological group, although its meetings are separate this year.

The program is expected to occupy three days, with almost continuous sessions and many sectional meetings. One hundred titles are listed on the geological society program alone, and the total of the four societies meeting at Cleveland will exceed one hundred and fifty, representing studies in nearly all branches of this earth science.

Major interest this year centers around large tectonic problems as represented by the symposium on "New Data on North American Structures." No less than twenty-five papers deal primarily with structural questions.

The principal addresses will be as follows:

Arthur Keith, president of the Geological Society of America, "Structural Symmetry of North America."

William A. Parks, president of the Paleontological Society, "Some Reflections on Paleontology."

Austin F. Rogers, president of the Mineralogical Society of America, "Natural History of the Silica Minerals."

Frederick L. Ransome, president of the Society of Economic Geologists, "Directions of Progress in Economic Geology."

The annual dinner will be held on Friday evening, December 30, at the Hotel Cleveland, at which time the newly established Penrose medal for distinguished achievement in geologic science will be awarded.

Charles P. Berkey,
Secretary

PRESENTATION OF THE ROYAL SOCIETY MEDALS

The awards of the Royal Society Medals have already been recorded in Science. Sir Ernest Rutherford, president of the society, in presenting the medals to Professor A. A. Noyes, Dr. W. D. Coolidge and Professor J. C. McLennan made the following citations:

The Davy Medal, awarded to Professor Arthur Amos Noyes

Professor Noyes's researches have been chiefly concerned with the properties of solutions, in particular of

electrolytic solutions. Soon after the inception of the electrolytic dissociation theory of Arrhenius, it was recognized that all was not well with the strong electrolytes. Whilst qualitatively their properties were accounted for by the theory, there yet existed marked quantitative discrepancies. Accurate measurement of the properties of such solutions was the first requisite for the attack of the problem, and to this task Noyes applied himself. His investigation of the conductance of aqueous solutions up to temperatures as high as 300° forms a classical example of exact physicochemical measurement executed under conditions of great experimental difficulty.

His work on the influence exerted by one salt on the solubility of another, on transport numbers and the mobilities of the ions, on the ionization of pure water at different temperatures, is all directed to the same end. Noyes showed the importance of the classification of the strong electrolytes according to their valency type and, more than twenty years ago, attempted to take into account the electrostatic forces between the ions. He thus foreshadowed the modern theory now so widely developed by Noyes himself amongst other workers.

The Hughes Medal, awarded to Dr. William David Coolidge

Science is under a great debt to Dr. Coolidge for the invention and production of a new type of X-ray tube, called by his name, of great flexibility and power, which has proved of great service not only to medical radiology but also in numerous scientific researches. In the last few years he has applied his unrivalled technical knowledge to the generation of high-velocity cathode rays, which can be passed into the air through a thin window as in Lenard's pioneer experiments thirty years ago. Such researches are of great importance to science, as they promise to provide us with new methods of obtaining a copious supply of swift electrons and high-speed atoms of matter for experimental investigations.

A Royal Medal, awarded to Professor John Cunningham McLennan

For more than thirty years Dr. J. C. McLennan has been an industrious and enthusiastic experimenter, his papers being mainly concerned with radioactivity, gaseous conduction of electricity, the spectra of the elements and the liquefaction of gases. Among his works of outstanding merit may be mentioned the measurements he has made with his pupils on the fine structure of spectral lines, which are of much importance to modern theories of the mechanism of the atom. Recently he has had quite sensational success in tracing to its source the elusive auroral line $\lambda 5577$, an extremely difficult task which had baffled the skill of many previous investigators. This is important not only in itself but also on account of the information it yields as to the structure of the upper atmosphere. Apart from his own private researches he has built up a most efficient school of physics in Toronto, and is largely responsible for the present strong position of physical science in Canada. He has devoted much energy to the establishment of a cryogenic laboratory in Toronto, a heavy task which he has carried out with much success.

SCIENTIFIC NOTES AND NEWS

The Edison medal, conferred annually by a committee of the American Institute of Electrical Engineers for "meritorious achievement in electrical science, electrical engineering or the electrical arts," has been awarded for the year 1927 to Dr. William D. Coolidge, assistant director of the research laboratory of the General Electric Company, "for his contributions to the incandescent electric lighting and to the X-ray arts."

The Catherine Wolfe Bruce gold medal of the Astronomical Society of the Pacific, given annually for "distinguished services to astronomy" upon the nominations made by six of the world's great observatories, has been awarded for 1928 to Dr. Walter Sydney Adams, director of the Mount Wilson Observatory. The formal presentation will be made in the early part of next year. Since its foundation in 1897, the medal has hitherto been conferred upon Simon Newcomb, Arthur Auwers, David Gill, Giovanni V. Schiaparelli, William Huggins, Herman Carl Vogel, Edward C. Pickering, George W. Hill, Jules Henri Poincaré, Jacobus C. Kapteyn, Oskar Backlund, W. W. Campbell, G. E. Hale, Edward Emerson Barnard, Ernest William Brown, Henri A. Deslandres, Frank W. Dyson, E. B. Baillaud, A. S. Eddington, Henry Norris Russell, R. G. Aitken and Herbert Hall Turner.

The board of managers of the Franklin Institute has voted to award to Dr. Vladimir Karapetoff an Elliott Cresson gold medal, "in consideration of the inventive ability, skill in design and detailed theoretical knowledge of kinematics and electrical engineering displayed in the development of computing devices." This medal will be presented at the annual medal day meeting of the institute, which will be held on May 16, 1928.

On the occasion of a celebration, marking the fiftieth anniversary of the founding of the Engineers' Club of Philadelphia, the University of Pennsylvania conferred the degree of doctor of science upon the following engineers on December 10: John Hays Hammond, of Washington, past-president of the American Institute of Mining Engineers; Charles M. Schwab, of New York, honorary member of the Engineers' Club and president of the Iron and Steel Institute, and Howard Elliott, of New York, chairman of the board of the Northern Pacific Railway.

At the annual meeting of the American Society of Mechanical Engineers in New York, the Melville medal, awarded for the first time, was given to Leon

P. Alford, editor of *Manufacturing Industries*, for his paper on "The Laws of Management."

THE Alvarenga prize for 1927 has been awarded by the College of Physicians of Philadelphia to Dr. Emil Bogen, of Cincinnati, Ohio, for his essay entitled "Drunkenness." The next award of the prize, amounting to about $300, will be made on July 14, 1928.

DR. GEORGE GRANT MACCURDY, of Yale University, director of the American School of Prehistoric Research, has been elected a corresponding member of the Société des Américanistes de Belgique.

Nature states that the Hopkins prize of the Cambridge Philosophical Society has been awarded as follows: For the period 1912–15, to Professor R. A. Sampson, astronomer royal for Scotland, for his researches on the internal constitution of the sun, on optical systems, on Jupiter's satellites and on practical chronometry; for the period 1915–18, to Sir Frank Dyson, astronomer royal, for his contributions to the general progress of astronomy and to the spectroscopy of the solar atmosphere; for the period 1918–1921, to Professor A. S. Eddington, Plumian professor of astronomy and experimental philosophy in the University of Cambridge, for his work on the classification of the motions of the stars, and on their structure, and on the influence of gravitation on rays of light; for the period 1921–24, to Dr. J. H. Jeans, secretary of the Royal Society, for his work on the theory of gases, and on radiation and on the evolution of stellar systems.

PROFESSORS A. EINSTEIN, of Berlin; O. Hölder, of Leipzig; F. Schur, of Breslau, and E. Study, of Bonn, have been elected corresponding members of the Bavarian Academy of Sciences.

THE following appointments have been made in the British Museum of Natural History: Dr. L. J. Spencer, to be keeper of mineralogy, in succession to Dr. G. T. Prior, who retired on December 16; Dr. W. D. Lang, to be keeper of geology, in succession to Dr. F. A. Bather, who retires next February, after forty years of service in the museum; J. Ramsbottom, to be a deputy keeper in the department of botany, on the promotion of Dr. Spencer; M. A. C. Hinton, to be a deputy keeper in the department of zoology, on the promotion of Dr. Lang.

THE Zoological Society of London has elected S. Zuckerman, M.A., University of Cape Town, to its research fellowship in anatomy, and Miss Eleanor Margaret Brown, B.Sc., University of London, to its aquarium research fellowship.

PAUL H. M.-P. BRINTON, professor of chemistry and head of the division of analytical chemistry in the University of Minnesota, has severed his connections with the university, and will devote his time to private research in rare element chemistry at Pasadena, Calif.

CLARK C. HERITAGE has been appointed to the vacancy caused by the resignation of John D. Rue, former chief of the section of pulp and paper in the Forest Products Laboratory.

C. W. LARSON'S resignation as chief of the Bureau of Dairy Industry was announced on December 1 by Secretary of Agriculture Jardine. The resignation will be effective at the end of this year, when Dr. Larson will become the director of the National Dairy Council.

BRUCE CARTWRIGHT has been appointed an associate in ethnology on the staff of the Bernice P. Bishop Museum. He has recently been engaged in mapping ruins on the Island of Molokai.

ACCORDING to *The Experiment Station Record*, Geoffrey Evans, formerly in the Indian Agricultural Service, has been appointed principal of the Imperial College of Tropical Agriculture. Henry A. Ballou, professor of entomology and head of the section of entomology and zoology, has been appointed by the British government to the newly established office of commissioner of agriculture for the British West Indies. He will retain his connection with the college, but will be occupied largely in an attempt to coordinate the scientific and practical work of the institution and the departments of agriculture of the various islands.

PAUL C. STANDLEY, of the U. S. National Museum, sailed from New York on November 26, to spend the winter in botanical field work in Honduras. The work is being undertaken in cooperation with the Arnold Arboretum and the United Fruit Company.

JAMES L. PETERS, associate in ornithology at the Harvard Museum of Comparative Zoology, and Edward Bangs started on November 29 on an ornithological expedition to the Corn Islands, off the coast of Honduras. They will also study the birds of an unfrequented desert region in Nicaragua, returning to this country in the late spring.

DR. RALPH LINTON, of the Field Museum of Natural History, recently returned from a two-year tour of Madagascar, where he assembled information indicating an ancient migration of people of an Asiatic origin to Southern Africa and Madagascar.

DR. G. J. HUCKER, associate bacteriologist at the New York State Agricultural Experiment Station, has returned after fifteen months spent in laboratory investigations at the Royal Polytechnical Institute at

Copenhagen and at the Lister Institute at London, under the auspices of the International Education Board.

Dr. E. C. Gray, exchange investigator of the League of Nations, after staying in Tokio for some time to investigate food problems in the government institute for nutrition, has left for England.

Dr. Luis Maria Torres, director of the Natural History Museum, La Plata, Argentina, recently concluded a visit to England, during which he worked at the Natural History Museum, South Kensington, London.

Dr. C. E. Spearman, of the department of psychology at the University of London, is visiting the United States as the guest of the Commonwealth Fund.

Professor J. W. McBain, of Stanford University, will give a series of five lectures in the department of chemistry at the University of Arizona during the first week of January. The general topic of these lectures will be: "Sorption: Its Nature and Mechanism."

At the recent intersectional meeting at Cornell University of the Western New York, Rochester, Syracuse and Eastern New York Sections of the American Chemical Society the main lecture was given by Dr. Colin G. Fink, of Columbia University, on "Recent Advances in Applied Electrochemistry." On the morning of December 10 Professor Paul Walden, of the University of Rostock, lectured on the "Walden Inversion."

The regular meeting of the Nebraska section of the American Chemical Society was held on December 1. Dr. W. D. Bancroft, of Cornell University, addressed the section on the subject of "Air Bubbles and Drops."

Dr. James A. Tobey, of New York, lectured on public health law at the Harvard University School of Public Health on December 7 and 9.

Captain M. E. Odell, of Toronto, addressed a joint meeting of the Washington Academy of Sciences and the Geological Society of Washington on December 7, on the "Scientific Aspect of the Mount Everest Expedition."

Dr. F. O. Rice, associate professor of chemistry in the Johns Hopkins University, addressed the New York University chapter of Sigma Xi on December 16, on "Suspended Particles in Gaseous and Liquid Systems."

Professor H. B. Ward, head of the department of zoology at the University of Illinois, gave a public address under the auspices of the University of Iowa on December 6. The subject was "The Significance of Life."

Dr. George Smith, director of the United States Geological Survey, will be the commencement speaker at Colby College next June. Dr. Smith was graduated from the college in 1893, and has been a trustee since 1903.

Dr. Harlow Shapley, director of the Harvard College Observatory, gave on December 14, before the department of astronomy of the Brooklyn Institute of Arts and Sciences, an illustrated lecture on "Measuring the Milky Way."

Dr. Robert Andrews Millikan, chairman of the administrative council of the California Institute of Technology, gave on December 14 the first of a series of lectures to be presented by visiting lecturers at Lafayette College on The Lyman Coleman Lecture Foundation for 1927–28.

Dr. C. Macfie Campbell, professor of psychiatry in the Harvard Medical School, recently delivered the eighth Pasteur lecture before the Institute of Medicine of Chicago on "Some Problems of the Functional Psychoses."

The rector of the Charles' University and the dean of the faculty of science, Prague, Czechoslovakia, have announced a course of lectures by Professor M. T. Bogert, of Columbia University, as the first visiting Carnegie professor of international relations to Czechoslovakia. The lectures are five in number, the first having been given on November 16, and the last being scheduled for January 18.

The first meeting of the executive committee of the American Association for the Advancement of Science will take place at 10:00 on Monday morning, December 26, in the executive committee parlor at the Andrew Jackson Hotel. The committee will meet at the George Peabody College for Teachers (Room 101, Industrial Arts Building) at 10:00 a. m. on Tuesday, Wednesday, Thursday and Friday from December 27 to 30. The council will meet in the Andrew Jackson Hotel Monday afternoon, December 26, at 2:00 o'clock. This will be the most important council session. Other council sessions are to occur at the George Peabody College for Teachers (Room 101, Industrial Arts Building) at 9:00 a. m. on Tuesday, Wednesday, Thursday and Friday. These sessions are to close by 10:00 o'clock. All members of the executive committee are members of the council. The chairman of the council is the president of the association. At 6:30 on Friday evening will occur, in the Andrew Jackson Hotel, the annual, complimentary, informal dinner and conference of the executive com-

ittee and the secretaries of the sections and of the ocieties meeting with the association at Nashville. The annual secretaries' conference is to follow the inner.

AMONGST the societies not meeting during Christas week in connection with the meeting of the Amerian Association for the Advancement of Science at Nashville it may be noted that the meetings of the merican Astronomical Society and of the American ection of the International Astronomical Union will e held at Yale University. The Society of American Bacteriologists will meet at Rochester, N. Y., and he Geological Society of America, the Paleontological Society, the Mineralogical Society of America and the Society of Economic Geologists will meet at Cleveland, Ohio. The American Psychological Association meets t Columbus, Ohio, and the American Anthropological Association at Andover, New Hampshire. The Archelogical Institute of America will meet at Cincinnati ith the College Art Association of America, the merican Philological Association, the Linguistic Soiety of America, the National Association of Teachrs of Speech and the American Association of Uniersity Professors. The meetings of the American Sociological Society, the American Political Science Association, the American Economic Association, the National Community Center Association, the American Association for Labor Legislation, the American Staistical Association and the American Historical Asociation will be held at Washington, D. C.

THE next annual meeting of the American Society or Testing Materials will be held at Atlantic City in he Chalfonte Hotel from June 25 to 29.

THE London correspondent of *Industrial and Engineering Chemistry* writes that preparations are now being made for the celebration next month of the jubilee of the Institute of Chemistry of Great Britain nd Ireland. The institute, of which R. B. Pilcher has been for many years the secretary and registrar, has done a great deal of work for the development of chemistry as a recognized profession and its degrees of "fellowship" (F.I.C.) and "associateship" (A.I.C.) rank high both as academic and practical qualifications. The jubilee celebrations will include a joint dinner, at which a very large attendance is expected, a reception and various other features.

THE first number has been issued of the *Quarterly Journal of General Psychology,* established by the late Edward Bradford Titchener and Professor Carl Murchison, and published by the newly established Clark University Press of which Professor Murchison is the director. The journal is planned to cover experimental, theoretical, clinical and historical psychology and has the cooperation of a number of editors representing different countries and the more important fields of psychology.

WORD has been received at the Harvard College Observatory from J. Hartmann, director of the observatory at La Plata, Argentina, that Maristany, also of La Plata, has observed a second magnitude comet with a tail. The detailed observation of the comet was right ascension 16 hours 27 minutes, declination minus 50 degrees. The Harvard observers stated that this comet was apparently the one discovered by S. K. Jellerup, a South African astronomer, at Cape Town.

THE Rockefeller Foundation has offered the University of Copenhagen a gift of half a million kroner for the erection and equipment of an institute of physical chemistry on condition that the Danish Government provides the site and maintains the work of the institute. The Rockefeller Foundation has previously provided funds for the erection of an Institute of Theoretical Physics and an Institute of Physiology, both of which are now in course of erection.

UNDER the will of Nathan Matthews, former mayor of Boston, Harvard University receives a portion of Mr. Matthews's, estate in Hamilton, known as Black Brook Farm, which has been planted and maintained as an experimental forestry station. The will directs that the station be continued for the benefit of all persons and institutions in New England interested in forestry.

THE late Professor A. Liversidge, F.R.S., has bequeathed to the department of minerals of the British Natural History Museum his mineralogical collection, comprising 3,000 specimens, mainly from Australia. This bequest includes a 65 pound mass of the Thunda meteoric iron and about 40 other specimens of meteorites; about 40 sections of gold nuggets, cut to exhibit their internal structure; and about 40 gem stones, besides lantern and microscope slides, photographs, etc. The trustees have authorized the purchase for the same department of two fine specimens of Dioptase crystals from the French Congo. In this connection they acknowledge the generosity of Mr. F. N. Ashcroft, who contributed half the cost of the best specimen.

PART of the famous Santa Rosa gardens, where Luther Burbank conducted many of his experiments with plant life, will be given to the municipality for a public park. Mrs. Burbank, having decided to sell three quarters of the three-acre garden plot for cutting up into building lots, is retaining the remaining quarter, on which is situated the Burbank home and the cedar of Lebanon, beneath which Burbank is buried, and this will ultimately be left in trust to the public.

BARRO COLORADO, an island in Gatun Lake, Panama Canal Zone, has been reproduced in miniature at the American Museum of Natural History, with its wealth of bird and animal life and tropical foliage. The exhibit was opened to the public on December 9. The island is the first of a series of twelve groups planned to illustrate bird life in the major faunal zones of the world. Barro Colorado is to be typical of the American tropics. The group was presented by Dr. Evan M. Evans, who was assisted in his work by Dr. Frank M. Chapman, ornithologist; Francis L. Jaques, who painted the background, and Raymond L. Potter, who mounted the birds. The foliage was reproduced in wax by James L. Clark, of the museum.

INDIAN objects and prehistoric relics, comprising the collection owned by Mr. Jonathan Tibbet, of Riverside, will soon be permanently exhibited at Pomona College as the gift of Mr. and Mrs. Tibbet, according to an announcement made by Mr. J. H. Batten, director of regional service for the college. The gift contains between five and six thousand separate articles, some of which date back to prehistoric days. The pioneer relics cover the entire period of California history, and have been secured from early families that Mr. Tibbet personally knew or from other trustworthy sources.

ACCORDING to a statement in *Nature* on the annual report of the British Photographic Research Association, the Department of Scientific and Industrial Research has offered to the association a block grant for the five years ending May 31, 1932, that will make up the income of the association from other sources (its members' subscriptions) to £5,000 per annum. There are certain conditions, and the one that is essentially new requires the appointment of a "research committee of technical and scientific persons in whom shall be vested the supervision of the scientific investigations of the association." Although the income of the association will probably be rather less than it has been, the useful work that it has been carrying on for the last ten years will be continued. The report gives the details of the last year's work.

THE cooperating agencies composing the New England Research Council, including agricultural experiment stations, state bureaus of markets and some of the universities of New England, were represented at the annual meeting of the council in Boston the latter part of October, according to a report by Nils A. Olsen, assistant chief of the U. S. Bureau of Agricultural Economics, in the *Record* of the U. S. Department of Agriculture. He says that a very much worth-while review was presented of all the research work that is going on at the individual stations. A general discussion of methods and problems arising in connection with the elasticity of milk supply studies was led by Mordecai Ezekiel, an economist of the division of farm management and costs of the bureau.

THE 1927–28 prize essay contests of the American Chemical Society will be conducted in a manner similar to that of the past four years with funds which have again been provided by Mr. and Mrs. Francis P. Garvin, of New York City. Contests will be conducted for high-school pupils, with prizes totalling $6,000 in cash and six four-year university scholarships of $500 annually; for university and college freshmen, with prizes totalling $6,000 in cash; for normal school and teachers' college students, with prizes identical with the freshman contest. The topics from which contestants must select subjects for their essays are: The relation of chemistry to health and disease, the relation of chemistry to the enrichment of life, the relation of chemistry to agriculture or forestry, the relation of chemistry to national defense, the relation of chemistry to the home and the relation of chemistry to the development of an industry or a resource of the United States.

UNIVERSITY AND EDUCATIONAL NOTES

THE Princeton University $20,000,000 fund committee reports that over $6,500,000 is now pledged towards the objective of the Princeton fund, which is to secure an increased remuneration for the faculty and to make possible a building program for the university. Toward the $2,000,000 fund for a foundation in pure scientific research over $1,400,000 is now pledged. Upon completion of the $2,000,000 fund the university will receive from the General Education Board its conditional gift of $1,000,000 for this purpose.

AMHERST COLLEGE has been promised a new chemical laboratory as the gift of Mrs. William Henry Moore, of New York City, and her sons, Edward Small Moore and Paul Moore, as a memorial to her husband.

AT a dinner held in New York on December 2 by the Near East College Association, a gift was announced, among others, of $1,000,000 from the Rockefeller Foundation to be devoted to medical work at the American University of Beirut. The Near East College Association announced at the dinner the opening of a campaign to raise $15,000,000 for the six American colleges in the Near East. Among other gifts announced was $1,000,000 from the estate of Dr. Charles Hall, who died in 1914.

THE University of Cambridge has become entitled to a bequest of approximately £65,000, accruing from

the residuary estate of the Rev. J. H. Ellis, M.A., of Trinity, to be used for general purposes as thought fit.

AT St. Louis University, Dr. Alphonse M. Schwitalla, A.M., Ph.D., has been appointed dean of the school of medicine to take the place of Dr. Hanau W. Loeb, recently deceased, and Dr. Don R. Joseph, formerly vice-dean, was promoted to the position of associate dean. Dr. James B. Macelwane was appointed dean of the graduate school to take the place of Dr. Schwitalla.

DR. HUBERT H. RACE, secretary of the Ithaca section of the American Institute of Electrical Engineers, has been appointed assistant professor of electrical engineering at Cornell University.

THE *Journal* of the American Medical Association states that Dr. Langley Porter, recently appointed dean of the University of California Medical School, has also been appointed professor of medicine and Dr. Lionel S. Schmitt, who has been the acting dean for several years, has been appointed associate dean and associate professor of administrative medicine, effective November 1. Dr. Schmitt, who is also a director of hospitals, was formerly clinical professor of dermatology.

DR. DONALD H. ANDREWS has been appointed assistant professor of chemistry at the Johns Hopkins University.

DR. T. M. MACROBERT, of the University of Glasgow, has been promoted to a professorship of mathematics.

M. BACHELIER, of the University of Rennes, has been appointed professor of the differential and integral calculus at the University of Besançon.

PROFESSOR H. LEO has been nominated professor of pharmacology at Bonn.

DISCUSSION AND CORRESPONDENCE

THE CONTROL OF DIABETES IN SIAM BY THE USE OF SOLANACEOUS PLANTS

IT may be of general interest to the readers of SCIENCE to learn of the existence in Siam of solanaceous plants whose fruit has a marked effect on the sugar content of the urine in diabetes, a disease that is quite prevalent in Siam.

The discovery of the virtue of these plants was made by the late Dr. Yai S. Sanitwongse, a graduate of the medical department of the University of Edinburgh, through having a friend, a native doctor, suffering from advanced diabetes, in whom the quantity of sugar excreted fluctuated in a remarkable manner from day to day, at times practically disappearing. By a process of exclusion, it was possible definitely to correlate the decrease of sugar with the ingestion of small fruits, taken with meals as a condiment. Later, the fruits were administered with the food in a number of cases of diabetes, always with marked effect, the sugar clearing up immediately and remaining absent from about twenty hours, but recurring unless the fruits were again taken. The daily use of the fruits in very small quantity at each meal kept the sugar in abeyance and led to improvement in the general condition of the patients, without any restriction in the diet, which always comprised a large proportion of rice. Special reference may be made to a striking case that has come to the writer's personal notice, that of a male European, about fifty-five years old, who had lived in Siam many years and developed diabetes in very severe form, with the usual loss of weight that proceeded to extreme emaciation. This man was induced to make a thorough trial of the solanaceous fruits. Beneficial results were noted immediately, so that in six months after he began treatment, and without the use of any other antidiabetics nor any systematic regulation of diet, his physical condition was vastly improved, the sugar was being kept entirely in abeyance, and he added thirty pounds to his weight. During that period he had taken at each meal ten of the little fresh fruits, and found that it was not necessary to increase the number, and in all probability that it might even have been feasible to reduce the quantity. The fruits produced no unpleasant gastric or intestinal symptoms. In December, 1925, the use of the fruits had been discontinued for about a year, and the health of the individual remained excellent. He then reported that sugar was usually entirely absent from the urine, and that it temporarily recurred only after some dietetic indiscretion, such as a very heavy meal of starchy or sugary food. In March, 1927, the general physical condition of the man continued to be good, there was no recurrence of the disease, and he had the satisfaction of feeling that should the diabetic symptoms reappear he had at hand a certain means of combating them.

The plants whose fruits have the noteworthy property indicated belong in the genus Solanum, but do not appear to have been positively identified as to species. There are at least two distinct forms, found wild over a large part of Siam. The fruits, which grow in loose clusters and resemble miniature tomatoes, are about the size of large peas or small grapes, and have a bright green color when immature, becoming yellow or orange when ripe. The taste is not unpleasant. The fresh fruits are said to be more potent, but the dried ones, even after some months, also produce a noticeable effect.

The news of the efficacy of these fruits in diabetes

has become known to the country people in several parts of Siam, and it is reported that sufferers from the disease are now using them with success, without any medical attention or advice. It is even stated that in several districts where diabetes is common the people are employing the fruits as a preventive! In the markets of Bangkok and other communities these fruits are now regularly exposed for sale as food by the small vendors of miscellaneous forest and jungle produce, and enough for five days' treatment may usually be obtained for the equivalent of five cents in United States money.

In the absence of full physiological and clinical data, it would be unwise to set up large claims regarding the therapeutic value of the plants in question, but from the information at hand it would appear that in these plants we have available a cheap, easily administered substance which has a noteworthy palliative influence on the sugar content of the urine in diabetes and may act like insulin. There is, furthermore, some evidence that under special conditions the effects may be regarded as curative.

It is believed that the known facts are so suggestive as to warrant a thorough investigation, and it is hoped that some workers or institutions in America or elsewhere may feel disposed to conduct a convincing test. Supplies of the fruits may undoubtedly be obtained through various agencies in Siam, such as the American Consulate, the Botanical Department of the Ministry of Commerce, and the Department of Public Health of the Ministry of the Interior, all in Bangkok. The plants are so hardy that they could probably be grown from seeds in subtropical parts of the United States, or in hot-houses anywhere.

HUGH M. SMITH

BANGKOK, SIAM

E.M.F. INDUCED IN A STRAIGHT WIRE BY A CURRENT IN A PARALLEL STRAIGHT CONDUCTOR

THE seeming paradox described by Professor Karapetoff, in the article under the above title, in SCIENCE of November 18, arises in its faulty premises.

The conception of current in a long straight conductor with open ends is not permissible. It would require an infinite electromotive force to set up such a current, but more important for the discussion, assuming the presence of the current, a finite change in its value is impossible, for such change would be accompanied by self-induced e.m.f. of infinite value, which is absurd. A long straight current-carrying conductor therefore must be part of a closed circuit. In such case, the central conductor must either be closed also, or stuck through holes in the outer conductor, or be of shorter length, terminating inside the outer conductor. In any one of these cases e.m.f. will be induced. In the last case of the open wire, the e.m.f. could not be measured; first, because the necessary instrument could not be connected, and second, because the e.m.f. would be too small to measure, the greater part of the total induced e.m.f. being consumed in the dielectric circuit closing the two ends of the wire.

The reasoning in the second case leads to the correct conclusion as regards such long straight conductors as arise in experience, but by means of unfortunate, and, I believe, unwarranted premises. Induced electromotive forces in both experiment and theory arise only from changes in the interlinkages of electric and magnetic circuits. The experimental fact needs no comment as clearly set forth by Professor Karapetoff. The theoretical origin of induced e.m.f. arises from the energy associated in the combination of a magnetic shell, or an electric circuit, with an external magnetic field, any change therein being reflected as an induced e.m.f. in the circuit, as shown in Neumann's expression. There is thus no warrant for the use of the idea of collapsing lines of force, or a conductor's cutting lines of force, except in so far as these offer convenient ways of computing changes in the total flux interlinking the electric circuit, which perhaps is only another way of expressing the conclusion reached by Prof. Karapetoff in his final paragraph.

J. B. WHITEHEAD

THE JOHNS HOPKINS UNIVERSITY

IN a recent number of SCIENCE Professor Karapetoff proposes the problem of finding the induced electromotive force in a straight wire due to variation of the current in a surrounding coaxial hollow cylinder. He presents two lines of argument which lead to different results, but recognizes that both methods of reasoning are open to objection, in that they are based on Faraday's circuital relation which is valid only for a closed circuit. His inference that it is not legitimate to speak of an electromotive force in a single straight wire does not, however, carry conviction to the present writer. For suppose the long hollow cylinder to be charged initially, positively at the upper end and negatively at the lower end. These charges, oscillating up and down, constitute a varying current, and if there is an axial electric intensity an oscillatory current will be induced in the central wire, whose presence can be detected by the heating produced without the necessity of attaching voltmeter leads to the ends of the wire.

The induced electromotive force in a secondary circuit fixed relative to the observer's inertial frame produced by a varying current in a fixed primary is

due to the portion of the electric field of the charges constituting the current which depends upon their acceleration. In the case of the open circuit under discussion the electromotive force along the central wire can not be calculated in any simple manner from Faraday's law, but it can be obtained at once from the series for the simultaneous electric field of a point charge given on page 40 of the writer's "Introduction to Electrodynamics." The necessary integration can be carried out without difficulty if we assume that the inner wire has a length small compared to that of the outer cylinder and is placed at the center of the latter. In this case the electric intensity along the axis is found to be

$$E = -\left\{\log \frac{1+\cos\vartheta}{1-\cos\vartheta} - \cos\vartheta\right\}\frac{di}{dt}$$

where both E and i are expressed in electromagnetic units and ϑ is half the angle subtended at the center of the tube by a diameter at either end. The current has been assumed to be uniform along the length of the tube, which would not be the case in the illustration previously mentioned. The electromotive force along the inner wire is obtained by multiplying this expression by the length of the wire. As the length of the outer conductor is increased $\cos\vartheta$ approaches unity and E becomes great without limit.

The electromotive force is the same as if the current were concentrated in a generating line of the hollow cylinder instead of being spread over its surface. Therefore we can check the formula given above by considering the former inner conductor to be one side of a rectangular circuit lying in the plane of the two conductors just considered and extending to infinity on the side away from the generating line. If we calculate the electromotive force along the long sides of the rectangle by the method employed above we get an expression per unit width of the circuit equal to the second term in the formula above, but opposite in sign. As the electromotive force in the distant short side of the rectangle is negligible, the total electromotive force around the entire circuit is given by the first term of the formula, for a rectangle of unit width. But if we calculate the magnetic flux through the rectangle and then compute the electromotive force from Faraday's law we are led to the same expression.

LEIGH PAGE

SLOANE PHYSICS LABORATORY,
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SIR JAGADIS CHUNDER BOSE AND HIS LATEST BOOK

THE delicacy of the political situation in India, the prominence of the Bose family, the unusual taste for biology possessed by one of its members, the strain of mysticism in the minds of all the East Indians with whom we come into contact—these factors and their sequelae have produced a singular situation in the scientific world. As a result biologists, or at least botanists, may be divided, without serum-diagnosis, as Bosephile or Bosephobe: and to have a neutral reaction is taken to indicate either a degree of ignorance or a feebleness of backbone quite deplorable.

In the first place, there is no question that Sir Jagadis Chunder Bose is the most distinguished biologist in India. The wealth of his family has secured for him freedom from economic anxiety, has built and supported for him the Bose Institute in Calcutta, where, under his directorship, the study of reactions to stimuli in the living and the lifeless is carried on in accordance with his tastes and methods.

Bose's recent book, "Plant Autographs and their Revelations," is the address of an enthusiast to an audience conscious of ignorance and desirous of enlightenment. From its dedication to his wife, "who has stood by me in all my struggles," to the last paragraph, "Not in matter but in thought, not in possession nor even in attainments, but in ideals, is to be found the seat of immortality," one sees the idealist, the mystic, dealing with facts too few in number, too incompletely understood, too imperfectly apprehended in their relations, quite too inaccurately measured and recorded, to justify conclusions put forward as knowledge. The conclusions are interesting, suggestive though not new, and are entirely legitimate if correctly labeled: but they are not science, they are not knowledge; they are belief, they are a philosophy of life, a guide and interpretation of conduct.

The trouble with Bose, as I see it with my occidental eyes and my American mind, is that while his curiosity is directed to biological phenomena, his mind is inadequately equipped with the information and the habits necessary for accurate study, and his reflections are addressed to philosophical problems. He is practical minded to the extent of using self-recording apparatus in his laboratory and social institutions in his human relations, but his ambitions exceed his capacities, his critical faculties are not applied to his methods and their results, his vocabulary outruns his findings. This may be illustrated by a quotation, typical of the whole book in spirit and defects: pp. 183–185. "Autographic Record of Assimilation:" "Water plants obtain their carbon from the carbonic acid dissolved in water. When sunlight falls upon these plants, carbonic gas is broken up, the carbon becomes fixed in the form of organic compounds known as carbohydrates, and an equal volume of oxygen is evolved which rises as a stream of bubbles from

the plant. The rate of evolution of oxygen indicates the rate of assimilation. Numerous difficulties were encountered in making this method practical; they have been overcome by my automatic recorder. A piece of a water plant, *e.g., Hydrilla verticillata,* is placed in a bottle completely filled with tank-water containing sufficient CO_2 in solution, the open end of which is closed by a special bubbling-apparatus, the bubbler, for measuring the oxygen evolved. The bubbler consists of a U-tube, the further end of which is closed by a drop of mercury acting as a valve. The oxygen evolved by the plant, entering the U-tube, produces an increasing pressure, which eventually lifts the mercury valve and allows the escape of a bubble of gas. The valve then immediately closes until it is lifted once more for the escape of another equal volume of gas. The movement of the mercury completes an electrical circuit, which either rings a bell or makes an electro-magnetic writer inscribe successive dots on a revolving drum (fig. 102). The automatic method eliminates all personal errors of observation; it is so extremely sensitive that it is possible to measure a deposit of carbohydrate as minute as a millionth of a gram. In illustration of the practical working of the apparatus I will give the following example. The plant with the apparatus is so placed as to face the northern light; the bell rings each time it has evolved a certain amount of oxygen representing an equal volume of absorbed CO_2. If a person now stands obstructing the light, the assimilation is slowed down and the bell now strikes at longer intervals. When strong sunlight is thrown on the plant, the successive strokes on the bell become greatly quickened. The plant is such a sensitive detector of light that it may be employed as a photometer for indicating the slightest variations in the intensity of the light of the sky."

I need not point out to the initiated the many individual faults, even errors, in this plausible and very interesting exposition, but certain comments may be made by the way. 1. Whatever may be the usage in India, or elsewhere in the English-speaking world, discussion has demonstrated that *carbon fixation* is a better term than *assimilation,* and that *photosynthesis* is still better because self-descriptive. 2. Water plants probably obtain as much carbon from carbonates and bicarbonates, where they are present, as from carbon dioxide which, in solution in water, may be *called* "carbonic acid." 3. "When sunlight falls upon these plants" much more happens than merely that "carbonic acid is broken up," for—to mention only one thing—the temperature rises, producing purely physical effects in the water, in the plant cells and tissues, and bubbles arise which are not wholly, and may not be even mainly, oxygen. Hence any apparatus devised to demonstrate photosynthesis and depending upon evolution of gas in water of unknown composition, of undetermined temperature, in unmeasured light, should be used for demonstration, graphic representation, but never for one moment considered as *measuring* "a deposit of carbohydrate." This has been recognized for so long in botanical laboratories in this country that the method is employed only on the lecture table, or in elementary laboratory experimentation.

I do not need to multiply quotations. "Resonant recorder," "acuity of perception," "the plant biophytum is found to be eight times more sensitive than a European and four times more so than a Hindu"—these also are fair samples of vocabulary, of deduction, and of aviation. It is a book as dangerous as it is fascinating. Would that it might be followed by a book of equal charm, but exhibiting the respect for the truth which keeps the occidental scientific man from mixing poetry, mysticism and grandiose generalization with his descriptions of the facts of nature! Nature is indeed more wonderful, more beautiful, more impressive than the products of man's imaginings, reflections and theorizings.

George J. Peirce

Stanford University

WHEN IS MID-WINTER?

I have long intended to answer the communication by Charles H. Briggs in Science for April 29, regarding the date of midwinter, but have delayed until I could speak from observational data. I have never before heard the shortest day called the middle of winter. One should hardly expect the coldest weather to fall then, for though it is the day when the hemisphere receives least sunshine, yet the general run of weather should continue to grow colder so long as the solar energy received per day is insufficient to replace the heat radiated to space. For this reason the curve of temperature shows a lag in phase as against that of sunshine.

Our texts of descriptive astronomy and most almanacs tacitly accept the amount of this lag as a month and a half, making the four seasons coextensive with the four quadrants of the sun's apparent motion, thus calling the shortest day the *beginning* of winter. This is an easy way of defining the seasons and one entirely independent of local conditions. Perhaps this last fact is one cause of its apparently wide acceptance.

In addition to the astronomical definition, Webster and other lexicographers give as the "popular" definition of the seasons, groups of three months each, beginning (for the U. S. A.) on March 1, June 1, September 1 and December 1, thereby antedating the astronomical seasons by three weeks. This has the

Station	Latitude	Longitude	Year's Record	Mean °C.	Annual Range °C.	Midsummer	Mid-winter
Estación Misionera	−23° 23′	+58° 25′	4½	24.6	10.1	Jan. 20	July 1
Asunción	25 18	57 40	7	22.8	11.2	" 13	June 30
Salta	24 46	65 24	16	17.4	7.4	" 10	" 30
Tucumán	26 50	65 12	7	18.7	13.2	" 9	" 30
Andalgalá	27 30	66 26	5	19.4	16.1	" 9	July 3
Córdoba	31 25	64 12	20	16.8	13.9	" 14	" 2
Rosario	32 56	60 39	11	17.7	15.0	" 18	" 5
La Plata	34 55	57 56	18½	16.3	14.3	" 21	" 15
Chos Malal	37 27	69 50	4½	14.1	16.1	" 18	" 9
Colonia 16 Octubre	43 5	71 20	5	9.6	15.0	" 22	" 9
Isla de los Estados	54 23	63 47	7	5.7	6.4	" 24	" 22
Isla Laurie	−60 43	+44 47	8	−4.4	1.21	" 6	" 14

qualities of simplicity and independence of local conditions just as fully as the other, and is more convenient for tabular work. Just how popular and widely accepted it is I do not know. The Oficina Meteorológica Argentina uses it, transposed, of course, in all their summaries, but I must confess that I had not heard of this definition till I had occasion to look into their work.

A rational definition of the seasons should be based on the characteristics of the annual temperature curve. This will perforce introduce the local element, but that is not necessarily disadvantageous. Mr. Briggs defines midwinter in a way which seems logically sound and quite acceptable, though the 60° F. is perhaps a bit arbitrary. That his date of midwinter and half the coal supply does not agree with the proverb he cites vitiates neither, for the proverb refers to hay, which with other crops does not become available immediately the cold weather is over, but later in the growing season. Half the store of these should consequently remain some time after midwinter.

Partly to furnish Mr. Briggs data from South America for comparison and partly to clarify my own ideas on the matter, I have summarized the La Plata temperature record[1] and have selected several other stations of wide geographical distribution from among the many discussed in the Anales de la Oficina Meteorológica Argentina. Since some stations have their annual range entirely above and another entirely below the 60° F. used by Mr. Briggs, a departure from his procedure was necessary. I have used as base line the general mean of the station and have defined midsummer and midwinter as the dates whose ordinates bisect the areas between the mean temperature and the observed temperature above it and below it, respectively.

From the table it will be seen that midsummer in Argentina, as determined, agrees closely with midwinter in the Twin Cities as defined by Mr. Briggs. On the other hand, our midwinter is appreciably earlier than the date he deduces for midsummer. There is also an indication of later dates for midwinter as one moves southward while the date of midsummer varies less uniformly and by a less amount.

I remember well the resentment felt as a boy when, on the occasion of a cold snap a week or so before Christmas, one of my elders remarked that winter had not yet begun. Perhaps this started vaguely the idea which has since become a conviction, that in the astronomical definition of the seasons the lag is grossly overestimated. In order to determine its true amount I have considered a tentative definition of the seasons on the basis of the temperature curve as follows:

That part of the curve of annual variation of temperature containing the maximum (minimum) and subtended by a horizontal chord 91 days in length is to be considered summer (winter); the intervening ascending (descending) portion is to be considered spring (autumn.)

Selecting from among the dozen stations used above those five with the longest series and applying this tentative definition to the smoothed ($9c' = a + 2b + 3c + 2d + e$) decade temperatures, I obtain as the first days of summer and winter the dates given below:

Station	Beginning of Winter	Beginning of Summer
Salta	May 17	Nov. 15
Córdoba	May 16	Nov. 30
Rosario	May 21	Dec. 2
La Plata	May 27	Dec. 6
Isla Laurie	May 29	Dec. 19

The progression of summer with latitude is remarkably strong. That of winter is less, but still well marked and in the same direction. Comparing these dates with those of the astronomical definition one sees that only summer at Isla Laurie agrees even

[1] The readings at 7 A. M., 2 P. M. and 9 P. M. over ten (eleven) day intervals were averaged and then the corresponding decades of each year combined.

approximately. Other dates for summer are from two to five weeks earlier and the dates for winter from three to five weeks earlier. Consequently the "popular" definition represents the facts for this Republic for better, and even that overestimates the lag for the northern provinces.

Bernhard H. Dawson

La Plata,
Argentina

QUOTATIONS

INTERNATIONAL CONGRESSES

Among the many things of value lost through the world war was that informal yet efficient organization known as the International Congress of Applied Chemistry, which was responsible for holding once in three years a scientific conclave, truly international in its attendance, work and publications. Four languages were official—French, Italian, German and English. Representatives on an equal footing came from everywhere and were welcome. Latest accounts of scientific progress furnished the keynote.

How well we remember the last of these international congresses in 1912! There was the gathering in Washington in Continental Hall, where the leader of each national delegation spoke following the playing of his national anthem by the Marine Band. There was a notable afternoon with the President of the United States, the reception, the half-day of sight-seeing and then the special trains to New York where the work of the congress was conducted.

Columbia University and the College of the City of New York fairly swarmed with hundreds of chemists. The meetings, held on the sectional plan according to subject, were open to all and at stated times the congress gathered to hear the principal addresses delivered by representatives of the leading foreign countries. Here we heard the glowing account of the development of the arc process in Norway by Eyde himself. Bernthsen demonstrated that nitrogen and hydrogen could be compelled to combine to form ammonia. Perkin discoursed on synthetic rubber, and the address of Ciamician on photochemistry remains a classic. No one who saw the multitude of products of industrial chemistry which Duisberg brought from Germany will ever forget that occasion in the great hall at City College. Of course there were banquets, sight-seeing, garden parties and receptions, but they were incidental. The congress did real work, as the twenty-nine volumes now on our shelves amply testify.

The International Congress was able to function without a continuous organization and without a paid secretariat and headquarters subject to national influences. The congress decided where its next meeting would be held, selected the man to be responsible at that place and left it to him to form his own organization, work out the details and proceed. The war spoiled the congress planned for 1915, which was to have been in Russia, under the chairmanship of Dr. Walden, the eminent scientist who is the visiting lecturer at Cornell this semester.

It is history that the war gave rise to scientific organizations in several countries, and it is but natural that these should have been the ones to form a new international organization. With the effect of the war still upon them, conditions were at first imposed which prevented the adherence of the former enemy countries to the new union, but fortunately those difficulties have been remedied and any country, the science of which can be represented through a central national body, is welcome.

At first the principal business of the International Union of Pure and Applied Chemistry, which is sponsored by the International Research Council, was the creation of good will and better understandings and beginning anew the promotion of scientific work on a true international basis. Although some committees for scientific work have been formed, it is patent that the union has added little, if anything, to the sum total of scientific knowledge and has devoted itself more to questions of policy and diplomacy through social activities. This has been going on for eight years, but for the last year or two the active members of the union have come to realize that if it is to survive and perform a useful function its program must be changed.

The union is too much restricted in membership and in the number of individuals involved to accomplish its own ends. At present it brings together far too few really to hasten the day of better international relationships. If augmented in numbers it meets too often, and at the basis of it all is the neglect of its real opportunity again to make available the advantages of the world international congress. It is conceivable that some of the work of the union would require the meeting of a small group more frequently than once in three years, provided the union can be looked upon as a sort of nucleus or holding organization to which is entrusted the promotion of chemistry, international so far as the science is concerned. This involves assuming responsibility for a scientific congress to be held very much along the lines of the old international congress.

This subject from time to time has been forcefully brought to the attention of the officials of the union and was discussed at the Washington meeting when Ernst Cohen, the president, stressed the importance of organizing a truly international congress of chemistry along democratic lines. At the recent meeting in Warsaw articles providing for such congresses were pre-

sented and incorporated into new statutes of the union. These articles were passed unanimously, but according to the union's rules must be held over until the next meeting, scheduled to take place in Holland in July, 1928. In order to avoid undue delay a committee has been set up charged with the formulation of detailed plans for such international congresses. It is expected, therefore, that with the adoption of the new statutes the union will be in position to act upon the report of the committee. It seems unfortunate that there should be even a year's delay for many are becoming impatient, and it is already fifteen years since the chemists of the world have gathered together in a congress organized along democratic lines and devoted to science.

We hope that the International Union of Pure and Applied Chemistry will take leadership in this matter and make the most of its opportunities. It would be unfortunate should it be found necessary to set up any other organization. — *Industrial and Engineering Chemistry*.

SCIENTIFIC BOOKS

Handbook of the Echinoderms of the British Isles. By TH. MORTENSEN. 471 pages, with 269 text-figures. Humphrey Milford, Oxford University Press, 1927.

IT is indeed gratifying that the Oxford Press should consider it possible to undertake the publication and general distribution of a large book dealing with a group as little known to the public as are echinoderms. The paper, printing, illustrations and binding are what we have learned to expect from the Oxford Press and are all that could be desired for such a volume. As the author occupies a preeminent position as a student of echinoderms, it is not strange that this handbook is by far the best general account of the group that has ever appeared. Taken as a whole, and considering the purpose in view, the volume is beyond praise. It is attractive in appearance, natural and thoroughly usable in arrangement, reliable in content and exhaustively complete for the area included. The number and quality of the illustrations are notable and enormously enhance the value of the book. Of course, there are some errors of both omission and commission, but they are chiefly of a trivial character or involve matters where there is room for difference of opinion. One detail that invites criticism is the use of capitals for specific names, derived from personal names. This is usual among botanists, but most zoologists long since abandoned it. Dr. Mortensen has, however, clung to botanical custom.

In an interesting preface Dr. Mortensen explains the inception of the book and the reasons for including under the term British Isles an area vastly more extensive than the term usually connotes. The whole Northeastern Atlantic Ocean from Iceland to the Cape Verde Islands is included within the scope of the book so far as the deep water forms are concerned; of course, only those littoral forms are included which are known from the British Isles themselves or may reasonably be expected to occur there. Hence the book will be of service not only in Great Britain but in most parts of Western Europe and, in connection with deep sea work, far to the north, west and south of the British Isles.

The book opens with an admirable general account of echinoderms, covering in a few pages the main features of the structure, development, larval forms and distribution of the group and concluding with a key to the five well-marked classes of Recent forms. Similar treatment of each of these five classes makes up the remainder of the book, some 30 pages being given to the crinoids, 103 to the asteroids, 109 to the ophiurans, 96 to the echini and 88 to the holothurians.

The section dealing with the crinoids, or sea-lilies, treats of a dozen species, actually known from the area under consideration, each of which is figured either wholly or as regards essential parts. The artificial keys, however, include no fewer than 24 species of 20 genera, distributed in 8 families; these additional forms are those which may be expected to occur in the region. The treatment of the crinoids is notable for its freedom from unnecessary technicalities and details, while at the same time it is thoroughly modern and includes the latest available information about these relatively rare animals.

The use of the term sea-star, instead of starfish, is the first thing that catches the eye in the section dealing with the asteroids. This is a natural and sensible change and it is to be hoped that all zoologists will note and adopt it; perhaps it is too much to hope that the inaccurate term "starfish" will disappear at once from literature, but let us hope its days are numbered. The classification of the sea-stars is still in a state of flux, certain of the recognized families and orders being well-defined natural groups, while others are unsatisfactory and artificial. Dr. Mortensen has adopted as simple and usable a system as the complexity of the problem permits, recognizing 3 orders, represented in the British area by 20 families. There are 67 genera and 114 species represented in the numerous and very valuable keys, but only 47 of the species are actually known from the region concerned. Of these, 43 are well figured,

and there are additional figures showing structural details. It is a very striking indication of the modern tendency towards small genera that the 47 species are placed in 39 genera; one genus (Solaster) has 3 species (but 1 of these is usually considered generically distinct!) and half a dozen genera have 2 representatives each—the remaining 32 genera have in the British area but 1 species each so far as at present known.

In dealing with the brittle-stars, Dr. Mortensen is again faced with the problem of an unsatisfactory classification, and, in the opinion of the present writer, treats it in an unsatisfactory way. In rejecting Matsumoto's classification, Dr. Mortensen returns to the old arrangement of the ophiurans in two orders, a distinctly backward step and quite unnecessary. There is no need of rejecting all of Matsumoto's work, much of it of very great value, merely because his first order, the Phrynophiurida[1] seems to be an unnatural assemblage. Probably we shall have to recognize 5, and possibly 6, orders, when we more perfectly understand the problem and have the necessary data. Mortensen finds it more difficult to make a satisfactory key to the 11 families of British (or potentially British) ophiurans, which he puts in the old heterogeneous order Ophiurae, than he does in the case of any other group, but he succeeds admirably in spite of the inherent obstacles. No fewer than 141 species of ophiurans, grouped in 48 genera, are indicated as potentially British but only 50 species are actually known from the area, as yet, and of these only about a dozen are found in shallow water. The bulk of this section of the book therefore, deals with forms, the average zoologist, even though a frequenter of marine laboratories, is never likely to see. Particular attention is paid to the larval forms and a key to the known larvae of British species is interesting and of real value. The discussion of the ecology of brittle-stars and of their parasites is particularly good.

In the handling of the echini, Dr. Mortensen is dealing with the group of which he is preeminently the master and this section is therefore, of great interest. The account of the morphology is clearly written and on the whole satisfactory, but in discussing the "lantern," the perignathic girdle of the test, with which it is intimately associated, is slighted and the important distinction between auricles and apophyses is ignored. No reference is made to the absence of the "compasses" in the "lantern" of clypeastroids. There is a little confusion about the use of the term "irregular echini" for while in the key to orders, the "Irregularia" are made to include the clypeastroids, elsewhere statements are made which indicate that Dr. Mortensen had the spatangoids only in mind. Thus (p. 262) the posterior gonad is said to have disappeared in the "irregular echinoids" whereas it is present in a large number of clypeastroids. The paragraphs concerning the larval forms and the key to those known from British seas are particularly important and useful. The classification used is open to little criticism and has the great merit of being simple and yet adequate. There are 33 genera and 53 species included in the keys but only 21 genera and 33 species are actually known from Great Britain. The illustrations in this section of the book are worthy of special praise. An interesting side-light on Dr. Mortensen's attitude towards rules of nomenclature is shown by a footnote on p. 321, in which he objects to quoting the name of the first *describer* of *Aëropsis rostrata* as authority for the species because it will deprive another more eminent authority of "the honour"!

The introductory pages to the section on holothurians are particularly good reading and give a very clear account of the class. The classification used includes results from some very recent researches and the keys are as good as can be prepared for a group so difficult of satisfactory preservation. The assistance of Dr. Elizabeth Deichmann in the preparation of many of these keys is cordially acknowledged. Some 44 genera and 116 species are regarded as potentially British but only 14 genera and 30 species are actually known as yet from the area, so that here as among the ophiurans, the book deals with a preponderance of forms which the average zoologist, even though he live at a marine laboratory, will never see. This is of course not a defect; it simply emphasizes the extraordinary scope of the book. Naturally the illustrations of holothurians are not as numerous or attractive as those in the other classes, but they are well-chosen and satisfactory.

The book concludes with a brief appendix, 8 pages of bibliography, a list of abbreviations used for authors' names, and no fewer than 5 admirable and very useful indexes. It is difficult to conceive of more satisfactory indexing. From any point of view the volume is a credit to those responsible for it and the Oxford Press, Professor J. Stanley Gardiner, who induced Dr. Mortensen to undertake the work, and the author himself are to be heartily congratulated. It unquestionably adds new honors and prestige to the record of the eminent Danish zoologist.

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[1] Dr. Mortensen wrongly calls it Phrynophiurae and uses the same erroneous termination for the other three orders.

IONIZATION BY POSITIVE IONS

THE question as to whether positive ions can ionize toms has been the subject of much controversy. xperimentally no direct evidence exists which will nable one to decide between the two apparently pposing views held. If one regards the phenomenon rom the point of view of the ionization of an atom y a moving charged particle in virtue of the action f the charge on the electron of the neutral atom, one ust agree with J. J. Thomson[1] that it is unlikely hat on this mechanism ions with less than a few thou-and volts equivalent of energy can ionize. On the ther hand, as J. Franck[2] points out, and as is indi-ated by certain phenomena in ionization by slow anal rays, in the discharge of electricity from posi-ively charged points, and from the temperature ion-zation observed by King,[3] and also by Noyes and Vilson,[4] we have definite evidence of the ionization of ases by impact between charged or uncharged atomic asses moving with velocities corresponding to only wo or three times the ionizing energy. These two pparently contradictory[5,1,2] views, together with the onflicting experimental evidence put forward in an ttempt to decide the question, have led to a good eal of confusion. In part this has been clarified by Joos and Kulenkampff[30] but not completely. In a eminar course the writer recently had the opportun-ity of reviewing the literature on the subject and with he benefit of the criticisms of his two colleagues, Pro-essor R. B. Brode and Dr. Arthur von Hippel, be-ieves that he has been able to clarify the situation still more and that he has been able to show that there s no real contradiction in the two views.

It is the purpose of this article to briefly set forth these conclusions. To do this we may regard three distinct processes. They are:

1. The ionization by *rapidly* moving *charged* par-ticles, *e.g.*, electrons, protons, and doubly charged He atoms.*

2. The ionization of molecules of a gas of lower or equal ionizing potential by ionized atoms or molecules which may be in motion or at rest (*e.g.*, an exchange of charge).

3. The ionization resulting from the impact of atoms or molecules, charged or neutral, which possess electrons and which have an energy which is a small multiple of the ionizing energy of one of the atoms.

1. The first class of ionizing processes is character-ized and governed by the classical laws of electro-dynamics and the laws of momentum and energy[6,7] with the limitation that energy transfer to an elec-tron of an atom acted on must follow the quantum conditions, [8,9,10] (*i.e.*, energy can only be absorbed if the electron in question receives a quantum of energy demanded by its change in status). The applications of these laws to the fast electron, the proton and the alpha particle, have been adequately proven by the agreement in order of magnitude between the pre-dicted results and observations. That is, the ioniza-tion by electrons (Whiddington's[7,11] law and possibly even the application to ionization for slower electrons, though the latter is more doubtful), by protons[12] and by α particles as calculated by Henderson,[8] Fowler,[9] Bohr[7] and others, agrees within a factor of two or three with the observations. These laws, as Thomson[1] points out, demand that ionization by such particles in virtue of the action of the charge ceases at velocities easily computed from laws of momentum and energy, corresponding to values of the order $5 \times 10^7 - 1 \times 10^8$ cm/sec. Such velocities correspond to energies of the order of the ionizing potentials for atoms in the case of electrons, to energies of the order of 2,000–3,000 volts for protons, and to energies of the order of 10,000 volts for alpha particles. The efficiency of this type of ionizing action is very high and is more or less successfully predicted from classi-cal theory, assuming the ionization potentials as ob-served to be correct.[7,8,9,10] The conclusions are sub-stantiated by the sudden cessation of ionization by α particles and protons[13] at the end of their range observed, and by the recent work of Dempster[14,5] on the long free paths of protons of 900 volts velocity. It is the only process by which such single charges can produce ionization.

2. The second class of phenomena belong, properly speaking, in that class of phenomena called "inelastic

[1] Thomson, J. J., *Phil. Mag.* 48, 1, 1924; and also 23, 454, 1912.

[2] Franck, J., *Zeits. f. Phys.* 25, 312, 1924; *Handbuch der Physik.* Vol. 23, p. 731.

[3] King, A. S., *Astrophys. J.* 48, 13, 1918, and many other papers in this journal.

[4] Noyes and Wilson, *Astrophys. J.* 57, 20, 1923.

[5] Rüchardt, E., *Handbuch der Physik*, Vol. 24, p. 99.

* Singly charged He atoms and all *rapidly* moving charged particles should be included here. As, however, these carriers also can act to ionize in other ways which confuse the issue, and in order to emphasize the mechan-ism of the process, these have been purposely left out as typical examples of this class.

[6] Thomson, J. J., *Phil. Mag.* 23, 449, 1912, "Conduc-tion of Electricity through Gases," pp. 370–382.

[7] Bohr, N., *Phil. Mag.* 25, 10, 1913, and also 30, 581, 1915.

[8] Henderson, G. A., *Phil. Mag.* 44, 680, 1922.

[9] Fowler, R. H., Proc. Camb. Phil. Soc. 21, 521, 1923.

[10] Loeb and Condon, *Jr. Frank. Inst.* 200, 595, 1925.

[11] Whiddington, R., Proc. Roy. Soc. 85A, 323, 1911; also 86A, 360, 1912.

[12] Dempster, A. J., *Phys. Rev.* 8, 656, 1916.

[13] Baerwald, H., *Ann. der Phys.* 65, 167, 1921.

[14] Dempster, A. J., Proc. Nat. Acad. Sci. 11, 552, 1925; also 12, 96, 1926; *Phil. Mag.* 3, 115, 1927.

impacts of the second class," first discovered experimentally by Franck[15] and Cario, and later observed directly by Erikson[16] and Harnwell.[17]

They explain many of the phenomena observed by Dempster[12] on canal rays of low velocity. They occur fairly readily, and are largely independent of the velocity of the carrier. It is, however, possible that through the third class of ionizing phenomena the energy of motion could be utilized to make this group include ionization by moving ions of appropriate velocity of molecules of higher ionizing potential. To date, however, no certain evidence exists for this extension, though from indirect observation it seems probable. This process obviously can not lead to the production of a very much larger number of charged carriers than the initial number of charged carriers. Thus in a great many problems of ionization by means of charged particles their importance is secondary.

3. The third class of processes are definitely established by the existence of temperature ionization observed by King[3] and treated theoretically exhaustively by Eggert,[18] by Saha,[19] and Fowler.[20] Even if some of the assumed quantities (*e.g.*, the energies of the atoms necessary for ionization in such a process) in the equations turn out to be in error by a factor of two or three, the correctness of the deduction is unquestioned. As regards other evidence for ionization of gas molecules by positive ions, or moving neutral molecules of relatively low velocities, the evidence is less clear if one exclude occurrences of the type of Class 2 above.[12] The evidence from direct measurement on positive rays has been seriously questioned by Horton and Davies[21] and by Hooper,[22] due to the fact that secondary emission of electrons from the walls through the positive ion bombardment and photoelectric phenomena were not rigorously excluded. The work of Baerwald and others[23] on emission of secondary electrons from metals by positive ion bombardment upholds this. Hooper concludes that if ionization of a gas by positive ions below 1,000 volts occurs, the process is very inefficient. He believes that at high pressures (where many collisions can take place and the ionization could be observed for inefficient agencies) there is some evidence that it occurs in his experiments. The evidence from the experiments on ionization phenomena in gases and sparking potentials in fairly uniform fields, as interpreted by Townsend,[24] has recently been seriously called into question[25,26] on the basis of the probable actions of positive ions or radiation on the cathode. Townsend[27] himself agrees that such processes would fit his equations as well as experimental uncertainty admits. He however points out that only by assuming ionization by positive ions of low velocity in a gas can we explain the discharge from positive points at high potentials.[28,29] In this assertion he is undoubtedly correct if we add the possibility that such ionization may be in part indirect as later described. There is thus evidence that neutral atoms, molecules, canal rays, and *slowly* moving positive rays directly or indirectly can ionize gas molecules by impact, though the efficiency of the process is obviously very low. This type of activity is, however, essentially different from that under Class 1 in *that it is independent of the charged state of the ionizing atom or molecule, so that the charge is but incidental to the mechanism*. The process, however, depends on one additional feature. *Every atom ionizing in this fashion must have at least one electron in an orbit about it, and possibly more.*

It is in fact the presence of the electrons in these ionizing systems that enables them to produce ionization independently of charge, and thus give a mechanism which can be clearly differentiated from the first class of ionization. With electrons in each of the atoms or systems colliding, transfers of energy between the electrons of the two systems again become possible at low velocities. However, it is difficult to postulate the exact mechanism of such transfers, in which the relative energies of two atoms are transferred to one or two of their electrons in a molecular impact. To date the new quantum mechanics has been unable to cope with the problem. The earlier discussions of Franck,[1] and Joos and Kulenkampff[30] treated the atoms as elastic spheres. If one could conceive of the electrons being rigidly held in stationary positions by the binding forces of the nucleus, interactions of the observed sort might be expected. Such an assumption enables one to find a plausible explanation for inefficiency of the process; for it would be a relatively rare atomic encounter that brought two electrons of the colliding atoms into such

15 Franck and Cario, *Zeits. für Phys.* 11, 3, 1922.
16 Erikson, H. A., *Phys. Rev.* 28, 372, 1926.
17 Harnwell, G. P., *Phys. Rev.* 29, 830, 1927.
18 Eggert, J., *Phys. Zeits.* 20, 570, 1919.
19 Saha, M. N., *Phil. Mag.* 40, 478, 1920.
20 Fowler, R. H., *Phil. Mag.* 45, 1, 1923.
21 Horton and Davies, Proc. Roy. Soc. 95A, 333, 1919.
22 Hooper, W. J., *Jr. Frank Inst.* 201, 311, 1926.
23 Rüchardt, E., *Handbuch der Physik*, Vol. 24, p. 105.
24 Townsend, J. S., "Electricity in Gases," Chap. IX, p. 322.
25 Holst and Oosterhuis, *Phil. Mag.* 46, 1117, 1923.
26 Taylor, James, *Phil. Mag.* 3, 753, 1927; also 4, 505, 1927, Proc. Roy. Soc. 114A, 73, 1927.
27 Townsend, J. S., "Electricity in Gases," p. 330.
28 Huxley, H. G. L., *Phil. Mag.* 3, 1057, 1927.
29 Townsend, J. S., "Electricity in Gases," p. 371.
30 Joos and Kulenkampff, *Phys. Zeits.* 25, 257, 1924.

relation that the energy of atomic motion was con-ntrated on one electron and thus made possible its scape. However, the electrons are more probably n orbits in the atoms and the flexibility of this type f binding, coupled with the experimentally observed act that the orbital momentum of electrons in atoms s not manifested in ionization processes,[31] makes it ifficult, if not impossible, to explain the facts in a imple mechanical fashion. We can only conclude at there exists a mechanism in atoms which in *rare ollisions by means of the interactions of the electrons the atoms enables the relative energy of the atoms o be transferred to one of the electrons.*

The presence of a positive charge on one of the wo colliding atoms at low velocities should affect the nization by such a mechanism but slightly. As Franck[1] has stated it increases the energy necessary o cause ionization, as with the charged atom the lectron must escape against an attractive charge of wo units instead of one. Besides this minor influence he charge plays an important indirect rôle, in low elocity phenomena, in that it enables a molecule or tom to acquire its ionizing energy from an electrical eld, an energy which it otherwise would practically ever acquire at room temperatures as a result of the eat motions. Such an atom or molecule having ac-uired the energy through its charge is then able to onize molecules itself, or perhaps is able by impact to mpart its energy to a neutral molecule which can onize slightly more effectively. In any case whatever ts manner of producing ions, the function of the harge is but indirect enabling the ion *to acquire nergy. It has little to do with the subsequent mech-nism of removal of electrons* by the ion, thus clearly ifferentiating its ionizing mechanism from that of wiftly moving charged particles.

It is also conceivable that one ion may ionize by ny two or even all three mechanisms simultaneously, lthough at high speeds the preponderating mecha-nism for an ion with electrons will be processes of Class 1, while as it slows down the processes of Class 2 and 3 will entirely predominate. At intermediate speeds probably all mechanisms are active and thus ead to some of the apparently contradictory results btained.

We thus see that in terms of the three different echanisms, the outstanding conflicting observations an be simply explained and it is seen that there is o essential contradiction even between the extreme iews of Thomson and Franck; for we have seen that either a proton nor a doubly charged helium atom an ionize below certain minimum velocities as classi-al theory demands that they should not, while hydro-en atoms, singly charged helium atoms and neutral helium atoms can be expected to ionize at low veloci-ties albeit very ineffectively.

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[31] Watson, E. C., *Phys. Rev.* 30, 479, 1927.

SPECIAL ARTICLES

CORRELATION BETWEEN ELECTRO-MOTIVE SERIES AND OXIDATION POTENTIALS AND PLANT AND ANIMAL NUTRITION

IN studying the distribution and the dominance of pasture plants, it was observed that there is a definite correlation between the dominance of certain pasture plants and the natural or native vegetation. An attempt was made to correlate the growth and dominance of the various plants with the soil acidity, but it was soon found that there is no very close correlation between acidity of the soil and the dominance of certain types of pasture plants.

Since no very definite correlation was found between the acidity of the soil and the growth and dominance of certain plants, an attempt was made to correlate plant growth with plant residues, particularly the basic nitrogenous materials, including ammonia, amines, etc., and here again only a partial correlation was found between the availability of the basic nitrogenous organic residues and plant growth.

The nitrogen carbon ratio in the organic residues probably affects the mobility of the nitrogen in the soil. There is a difference in the nitrogen carbon ratio in various plant residues. The difference in the nitrogen carbon ratio in peat soils illustrates the points in question. It has been found that some peat soils have a nitrogen carbon ratio as narrow as 1 : 8, while others have a ratio as wide as 1 : 70 or wider. This difference in nitrogen carbon ratio undoubtedly affects the availability of anionic nitrogen. It has been found that there is a close correlation between the calcium oxide content and the width of the nitrogen carbon ratio in peat soils. Where the nitrogen carbon ratio is narrow, it indicates that there is a relatively large amount of high oxidation potential mineral basic material present. And in such a situation it has been found that there is often an accumulation of toxic amounts of nitrates. But when the nitrogen carbon ratio is wide it indicates that there is a limited amount of high oxidation potential mineral basic material present. And where such a condition prevails it may result in a prolonged nitrogen starvation period, especially early in the growing season. Where the nitrogen carbon ratio is very wide such plants as some of the conifers, poverty grass (*Danthonia spicata*), certain species of Agrostis, etc., which may readily utilize cationic nitrogen, are apt to dominate in nature. Other plants, such as certain species of oak, hickory, poa, etc., seem

to grow best when supplied with anionic nitrogen. It is not possible at present to say whether anionic nitrogen determines the growth response of plants or whether it is the nutritional complex commonly associated with available anionic nitrogen. Wide nitrogen carbon ratios would very probably have much less effect upon the mobility of the cationic nitrogen from organic residues. The basic nitrogenous materials from such residues undoubtedly function similarly to mineral bases in the soil colloidal complex. These organic bases may partially satisfy the basic needs of the soil colloids, but the oxidation potential of such materials is apparently not sufficient to produce optimum growth of many plants. The low oxidation potential of basic organic materials may partially account for the lack of close correlation between the hydrogen-ion concentration of a soil solution and plant growth. The desirable crop sequence in rotations and the succession of native plants on abandoned crop land, as well as the succession of plants on virgin soil, is probably closely correlated with the ability of various plants to utilize cationic nitrogen or non-ionized nitrogenous materials. Basic material is very often the limiting factor in many of our depleted soils. Nature has an abundant potential supply of basic material in the nitrogen of the atmosphere, but apparently many plants can not readily utilize low oxidation potential cationic nitrogenous materials.

After failing to find sufficient correlation between the acidity of the soil and the availability of the basic nitrogenous organic residues to account for the difference in plant growth and associations, an attempt was made to correlate plant nutrition with the electromotive series and oxidation potentials. As life is probably dependent upon a difference in electrical potential it was believed that the electromotive series and oxidation potentials, which are the best single expressions of the properties of ions, would correlate with plant growth. The entire chemical activity of the metals corresponds fairly closely with the above series. Here we found a very striking correlation between the electromotive series and the absorption of plant nutrients. Indeed the electromotive series may be the key to many of the perplexing problems in plant and animal physiology. The various ions differ very much in the voltage they produce. Such ions as K, Na and Ca produce high voltages, other ions, such as Mg, Al, Mn, NH_4, amines and other basic nitrogenous materials, produce medium voltages, while still other ions, such as Fe, H. As, Cu, Hg, etc., produce very low voltages. Various plants and animals apparently tolerate different potential levels. Many crop plants, such as alfalfa, sweet clover, celery, barley, millets, asparagus, beets, etc., seem to be tolerant of very high electrical potentials as, for example, the potentials produced by high concentration of such ions as K, Na and Ca, often encountered in semi-arid to arid climates. Other plants, such as blackberry, blueberry, cranberry, raspberry, strawberry, oats, buckwheat, red top, cotton, sweet potatoes, watermelons, etc., grow well at relatively low potential levels as, for example, the potentials produced by high concentration of such ions as Mg, Al, Mn, NH_4, amines, protein acid salt ions, Fe, H. etc. It is evident that a given H-ion or OH-ion concentration resulting from the presence of various acidic or basic materials may produce different oxidation potential levels or physiological gradients. The gradients produced by such high potential materials as K, Na, Ca, etc., would be different from the gradients produced by such low potential materials as NH_3, amines, etc. Hence a close correlation between H-ion concentration and plant growth could not be expected.

Cropping may deplete various soil types until they reach approximately the same biological fertility level as, for example, the fertility level suited for the dominance of pine, etc. Since the accumulation of basic nitrogenous materials is one of the important factors in the natural restoration of the productivity of soils it is evident that the climax vegetation on different soils would be different, depending upon the ability of the soil colloidal complex to retain organic bases. Mass action resulting from the accumulation of organic bases may make available mineral bases that have a higher oxidation potential. The capacity of the soil colloidal complex to retain the organic bases may partially determine the climax vegetation. The above condition is probably one of the important factors controlling the more or less definite plant successions in the depletion and the restoration processes of various soil types. Therefore, certain soil types can not be restored above the pine fertility level while others may be restored to levels suited to the various hard woods.

It has been possible to trace the influence of the oxidation potential levels from plutonic magmas to the various igneous rock, thence to the soil colloids and finally through the plant to the animal. The ash of certain plants, such as alfalfa, sweet clover, foxtail millets, etc., grown in semi-arid to arid climates may contain very large amounts of potash. Ionic potassium may produce a very high voltage and it is, therefore, very readily absorbed by plants. Under certain conditions the rapid absorption of the potassium or similar ions may exclude or limit the absorption of other desirable nutrient cations. The feeding of large quantities of plants with high potash content may seriously affect animals. Another striking example of the effect of a high oxidation potential material is the probable correlation between high potash content in

rtilizers and tip burn in lettuce on certain high lime eat soils. It is necessary to have liberal amounts of otash to produce a satisfactory lettuce head, but if cessive amounts are added there is great danger of p burn developing and this may result in a loss of e entire crop.

Selective or differential absorption of nutrients by ganisms is probably largely determined by the oxition potential of the various ions. The electrootive series and oxidation potentials are probably the y to the interpretation of the important works on tagonism and selective absorption by W. M. Bayliss, . M. Child, G. W. Crile, D. R. Hoagland, J. Loeb, . M. McCool, W. J. V. Osterhout, W. Stiles and merous other investigators.

The bimodal growth or production curve so freently met with in plant and animal physiology is robably closely correlated with the electromotive ries and oxidation potentials. The hydrogen ion ith an ionic velocity nearly five times greater than y other common nutrient cation very probably deterines the mode on the acid side of the neutral point, d the hydroxyl ion with an ionic velocity nearly ree times greater than any other common nutrient ion determines the mode on the alkaline side of the eutral point. These two high velocity ions greatly fluence the absorption of other ions, and are thus ery important factors in regulating the growth or evelopment of organisms.

This paper is an attempt to outline briefly the sigificance of the correlation between the electromotive ries and the oxidation potentials, and the nutrition f plants and animals. A more comprehensive stateent of the whole subject will be presented in a later aper. It is very clear from the preliminary correlaions which have been made that the electromotive ries and the oxidation potentials afford a new and an nportant approach to the whole field of biology. lectrochemistry has illuminated the subjects of chemtry and physics. It will do likewise in the field of iology, when the biologist begins to appreciate more ully the relationship between electrochemistry and ital phenomenon.

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J. K. Wilson

Cornell University

NHIBITION OF ENZYMATIC ACTION AS A POSSIBLE FACTOR IN THE RESISTANCE OF PLANTS TO DISEASE[1]

Speculations and investigations on the nature of isease resistance in plants have occupied the minds and efforts of plant pathologists since the inception of the science of phytopathology in the classic work of de Bary.[2] Fragmentary as is the evidence for the correlation of specific factors with specific internal resistance of certain species or varieties to particular parasites, it is sufficient to indicate that ultimate elucidation will probably be found in the domain of biochemistry.

During the course of an investigation which seeks to throw some light on possible bases for the resistance of sour orange (*Citrus aurantium* L.) and for the susceptibility of lemon (*Citrus limonia* Osbeck) to the bark diseases known as *Pythiacystis gummosis* and *decorticosis*, it has been found that the trunk bark of sour orange has a much greater inhibitory or paralyzing influence on the action of certain enzyms found in the dried mycelial powder of the causal fungi than does the trunk bark of lemon. This suggests the possibility that resistance to the invasion of the pathogens may be due to the inhibition of one or more of the enzyms of the fungi by some cellular product of the host, and that a sufficient decrease in this paralyzing power might permit the hyphae to progress rapidly, as they do in the bark of the susceptible lemon, and successfully parasitize the host.

Table 1 shows that the hydrolytic action of the diastase and invertase found in the dried mycelium of both *Pythiacystis citrophthora* and *Phomopsis californica* was inhibited more by sour orange bark than by lemon bark. Bark of tangelo, a hybrid of pummelo and tangerine, which has been found by inoculation tests to be very resistant to Pythiacystis, showed about the same degree of inhibition of fungus diastase and ptyalin as sour orange did. It is not to be expected that all enzyms would be similarly affected. Urease in fact was not thus inhibited. Other enzyms are being tried.

The "cultures" were made by placing in a 200 ml. Erlenmeyer flask 20 ml. of the substratum, 500 mgm. of the bark and 250 mgm. or 5 ml. of the enzym source. One ml. of toluol was added as a preservative, the flasks tightly stoppered, and the "cultures" incubated in the dark for 36 to 48 hours at 40 degrees C. At the end of the incubation period the "cultures" were filtered and a 10-ml. portion of the filtrate placed in 25 ml. of solution A of Fehling's reagent to stop enzymic action. Reducing sugars were determined by the Shaffer and Hartmann iodometric method[3] and the results calculated as milli-

[1] Paper No. 173, University of California, Graduate chool of Tropical Agriculture and Citrus Experiment tation, Riverside, California.

[2] Bary, A. de, "Ueber einige Sclerotinien und Sclerotienrankheiten," *Bot. Ztg.* 44: 377–381, 1 fig.; 393–404, 409–426, 433–441, 449–461, 465–474, 1886.

[3] Shaffer, P. A., and Hartmann, A. F., "The Iodometric Determination of Copper and its Use in Sugar Analysis," *Jour. Biol. Chem.* 45: 349–390, 1920.

TABLE I

Inhibition of Enzymic Action by Citrus Bark

No.	Substratus	Source of enzym	Inhibition due to: Sour-orange bark mgm. Cu.	Lemon bark mgm. Cu.	Tangelo bark mgm. Cu.
1	10 per cent. Sucrose	Pythiacystis	3.6482	-.1664	——
2	1 per cent. Sucrose	Pythiacystis	6.9488	3.8184	——
3	1 per cent. Lintner's starch	Pythiacystis	14.2406	11.6272	——
4	1 per cent. Lintner's starch	Malt diastase	9.9416	6.4328	——
5	1 per cent. Lintner's starch	Phomopsis	16.2636	13.0835	——
6	1 per cent. Lintner's starch	Pythiacystis	12.1254	8.4568	12.0162
7	1 per cent. Lintner's starch	Saliva	14.4352	10.8264	14.7475

grams of copper. The intrinsic reducing power of both the active and autoclaved bark and enzym materials in water was used in all the calculations. To illustrate:

$$\left(\begin{array}{c}\text{Reduction}\\ \text{by enzym}\\ +\text{ substrate}\end{array}\right)-\left(\begin{array}{c}\text{Reduction}\\ \text{by enzym}\\ +\text{ water}\end{array}\right)-\left(\begin{array}{c}\text{Reduction by}\\ \text{autoclaved}\\ \text{enzym + substrate}\end{array}\right)+\left(\begin{array}{c}\text{Reduction by}\\ \text{autoclaved}\\ \text{enzym + water}\end{array}\right)=$$

Reduction due to the hydrolytic products of enzymic action.

The necessity for such a method of calculation was pointed out by Klotz[4] and is here illustrated farther. Suppose

		Mg. Cu.
	A. Starch solution plus active enzyme gave a reduction	25
and	B. Active enzym alone	5
and	C. Starch solution plus autoclaved enzym	2
and	D. Autoclaved enzym alone	1
and	E. Starch solution alone	0

then it is seen that the inactivated enzym in the presence of the substrate (starch) produces some substance capable of reducing Fehling's solution; that is, there is present a catalytic effect other than the enzymic effect. It is assumed that this property also resides in the active unheated enzym. Therefore, the reduction due to hydrolyzed starch, that is, the reduction due to truly enzymic action is evidently not A minus C or 25 minus 2 equals 23, but A minus B minus C plus D or 25 minus 5 minus 2 plus 1 equals 19. The value of D (equals 1) must be added because the intrinsic reducing power of the autoclaved enzym was present also in *C*.

The figures in Table 1, it should be noted, do not represent actual copper reduced, but inhibition expressed in milligrams of copper per milliliter of filtrate. They were obtained by subtracting the reduction value of the system, enzym + bark + substrate, from the sum of the values of the two systems, enzym + substrate and bark + substrate; that is, the figures represent loss in reducing power due to the inhibiting effect of the bark on the fungus or *vice versa*. Each horizontal row of results represents a series of cultures. The bark of the first five series was obtained from twelve-year-old lemon trees growing on sour-orange stocks, approximately equal quantities of bark above and below the bud union being taken at the same time. The bark material of lemon and tangelo reported in series 6 and 7 was from twelve-year-old lemon trees in another orchard and the sour-orange bark from a seedling tree near the tangelo. Inoculation tests have indicated that seedling trees of sour orange may be slightly more resistant to *Pythiacystis gummosis* than sour orange used as a stock.

The above data are offered as a suggestion for a possibly new line of attack. So far as is known this inhibiting or paralyzing effect of the plant tissues themselves upon certain fungal enzyms has not been suggested or tested as a possible basis for disease resistance in plants. The paralyzing effect on enzyms of some of the end-products of enzymic reactions, as hydrocyanic acid, benzaldehyde and hydroquinone, and also of the salts of heavy metals, is well known. It is suggested that any one or more of several cellular products might behave similarly. In work of this kind the necessity for check determinations on all materials used is here stressed again. The extension and test of the idea with other hosts, pathogens and enzyms are being continued at this station and it is hoped that others may see fit to test it.

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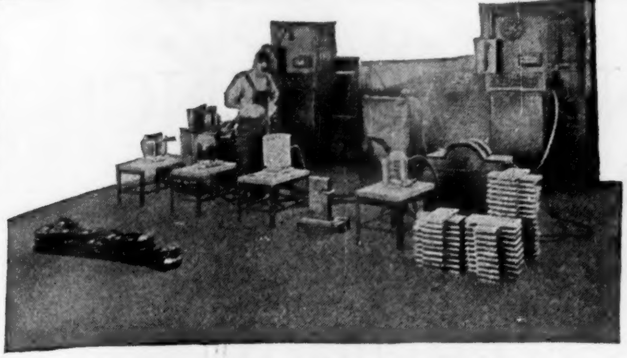
[4] Klotz, L. J., "The Enzyms of *Pythiacystis citrophthora* Sm. and Sm.," Hilgardia 3: 27-40, 1927.



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